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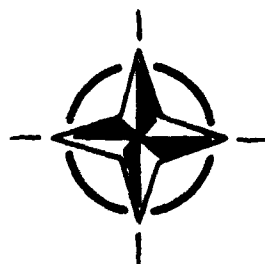
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Nutrition, Metabolic Disorders and Lifestyle of Aircrew

(Les Désordres Métaboliques Dus à la Diététique
et Hygiène de Vie des Equipages d'Aéronefs)

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*Papers presented at the Aerospace Medical Panel Symposium held
in Oslo, Norway from 19th—23rd October 1992.*

NORTH ATLANTIC TREATY ORGANIZATION

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North Atlantic Treaty Organization
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Preface

The dietary and lifestyle habits of the general population of the NATO nations have been found to be reflected in their Air Forces. Unfortunately, the implications of the end results of such habits are of utmost concern to NATO command as they directly affect pilot performance and thus the ultimate efficiency of air operations. Hyperlipidemia has been demonstrated to be a universal problem in every NATO Air Force. Cigarette smoking, in spite of years of clear evidence of its deleterious effects, is still quite common among pilots. Other cardiovascular risk factors including obesity, sedentary behaviour, diabetes and emotional stress are also found in the aviator population.

Pilot performance is not only influenced by the problems discussed above which are shared by the general populace, but also by some stressors specific of the flying environment. These include crew rest and fatigue which are often exacerbated by time zone shifts and also by environmental extremes. Because of the necessity that aircrew function at continually superior levels in order to successfully meet the demands made of them by modern equipment and complex mission plans, it is clear that even the slightest deviation from optimal performance caused by nutritional, metabolic or lifestyle factors should be of great importance to the flight surgeons charged with their care.

Préface

Le mode de vie et le régime alimentaire des populations des pays de l'OTAN sont reflétés dans le comportement des personnels des forces aériennes de l'Alliance. Ceci est un sujet de préoccupation majeur pour le commandement de l'OTAN, car malheureusement, les conséquences finales de tels comportements ont un effet direct sur les performances des équipages et, par conséquent, sur l'efficacité des opérations aériennes. L'hyperlipidémie est un problème universel qui touche toutes les forces aériennes de l'OTAN Malgré les effets néfastes occasionnés par l'usage de la cigarette, largement mis en évidence depuis de nombreuses années, le tabagisme est chose fréquente chez les pilotes. Parmi les autres facteurs de risque cardiovasculaires rencontrés dans les populations d'aviateurs on distingue; l'obésité, le comportement sédentaire, le diabète, et le stress émotionnel.

Les performances des pilotes ne sont pas influencées seulement par les problèmes que nous venons d'évoquer, qui sont également vécus par le grand public, mais aussi par certains éléments stressants qui sont spécifiques du milieu aéronautique. Ces éléments comprennent le cycle repos-fatigue des équipages qui est souvent exacerbé par des changements de fuseau horaire et des conditions climatiques extrêmes. Etant donné la nécessité, pour les équipages, d'opérer à des régimes constamment supérieurs afin de pouvoir répondre aux exigences imposées par le matériel moderne et les plans de mission complexes, il est clair qui le moindre écart des performances optimales occasionné par des facteurs alimentaires, métaboliques ou de train de vie est d'une importance capitale pour les médecins de l'air responsables de leur santé.

Aerospace Medical Panel

Chairman: Prof. G. Santucci
Sous-Directeur de Recherche de
   l'E.A.S.S.A.A. et du C.E.R.M.A.
Base d'Essais en Vol
91228 Brétigny sur Orge Cedex
France

Deputy Chairman: Prof. Dr Med. L. Vogt
Institut für Flugmedizin
DLR
Postfach 90 60 58
Linder Höhe
D-5000 Köln 90
Germany

TECHNICAL PROGRAMME COMMITTEE

Chairman: Major C. Alonso-Rodríguez
Centro de Instrucción de Medicina Aeroespacial
C. Arturo Soria, 82
28027 Madrid
Spain

Members

Colonel P. Burgers
IGDKLu/Hoofd
Luchtvaartgeneeskunde
Postbus 153
3769 ZK Soesterberg
The Netherlands

Colonel G.E. Schwender
Commander
Armstrong Laboratory AL/CD
Brooks AFB, Tx 78235-5301
United States

Dr J. Tangney
Directorate of Life Sciences
AFOSR — Building 410
Bolling AFB, Washington D.C. 20332-6448
United States

Medecin Colonel P. Vandenbosch
VSM — Director Aeromedical Services BAF
Kwartier Koning Albert ler
Raketstraat 70
B-1130 Brussels
Belgium

LOCAL COORDINATOR

Prof. H.T. Andersen
Director
RNOAF Institute of Aviation
   Medicine
P O Box 14, Blindern
0313 Oslo 3
Norway

PANEL EXECUTIVE

Major W.D. Lyle, CAF

Mail from Europe:
AGARD—OTAN
Attn: AMP Executive
7, rue Ancelle
92200 Neuilly-sur-Seine
France

Mail from US and Canada:
AGARD—NATO—AMP
Unit 21551
APO AE 09777

Tel: 33(1)47 48 57 60
Telex: 610176 (France)
Telefax: 33(1) 47 38 57 99

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Round Table with an Open Discussion†

SESSION IV — AIRCREW LIFESTYLE AND PERFORMANCE

† No paper available.

SESSION V — INFLUENCE OF DIET AND LIFESTYLE ON AIRCREW PERFORMANCE

Round Table with an Open Discussion†

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† No paper available.

TECHNICAL EVALUATION REPORT

by

César Alonso Rodríguez
Department of Aviation Medicine
Centro de Instrucción de Medicina Aeroespacial
C. Arturo Soria 82
28027 Madrid
Spain

1. INTRODUCTION

The Aerospace Medical Panel Symposium on "Nutrition, Metabolic Disorders and Lifestyle of Aircrew" was held in Oslo, Norway, the days 20 and 22 of October of 1992. Thirty papers representing eleven NATO nations constituted the main programme. These presentations were supplemented by two round table discussions conducted by experts in related topics.

2. THEME

When originally proposed in 1988, the content of the symposium exclusively considered the nutrition and its associated metabolic problems in aircrew. The special clinical and physiological problems in military aviation committee, chaired at this time by Air Commodore Ernsting, accepted the proposal of other members to include in the symposium the lifestyle aspects of aircrew, a topic which could be considered by itself a theme for a separate conference. Nevertheless due to its predicted limited extension and the relation with the nutrition in the maintenance of the aviators health, the majority of the members were in favour of a mixed symposium including three interrelated topics: diet and nutrition, metabolic disorders and lifestyle in aircrew.

The importance of these three topics derives from the fact that acting upon them is one of the best ways to improve the physical and psychological fitness and consequently the performance of aircrew.

The AMP finally approved the symposium at the meeting in London in October of 1990 where the following programme committee members were appointed: Col. P. Vandenbosch (BE), Col. P. Burgers (NB), Col. G. Schwender (US), Dr. P. Tangney (US) and Maj. C. Alonso (SP).

3. PURPOSE AND SCOPE

The great importance of ensuring a suitable nutritional balance according to the different aircrew activities, as well as prevention, early detection and adequate treatment of related metabolic disorders is widely accepted. Modification of undesirable lifestyle habits such as lack of exercise, smoking habit or alcohol abuse must be undertaken in order to improve the general health and ultimately the performance of the aircrew member . In addition one must address problems peculiar to the extended aircrew missions including fatigue and sleep disturbances and special dietary needs.

The scope of the symposium will encompass presentation and discussion of specific policies of the different NATO nations as they relate to aircrew diet, prevention and management of metabolic disorders , assessment and control of cardiovascular risk factors and the realization of the importance that aircrew sleep and fatigue play on the result of the air missions. The discussion will ultimately result in incorporation of this new knowledge within the framework of the air and ground operations leading to general recommendations which can be used by flight surgeons in order to increase the health of aircrews and consequently the operational capacity.

4. SYMPOSIUM PROGRAMME

The initial call for papers was distributed in september 1991, soliciting five major areas of interest: (1) Principles of dietetics and nutrition applied to aircrew, (2) Assessment of nutritional status of aircrew, (3) Metabolic disorders in aircrew, (4) Catering facilities, and (5) Hygiene of the pilot.

The expected five sessions in which the meeting was supposed to be divided were rearranged in only three according to the content of the available abstracts, as follows: Session I, Dietetic and nutrition applied to aircrew, with seven papers ; Session II, Metabolic disorders and cardiovascular risk factors in aircrew, with fifteen papers, and; Session IV, dealing with the aircrew lifestyle and performance, with seven more papers. As the content of the abstracts did not cover all the areas solicited we decided to include two additional sessions organized as round tables with a double goal. First, to fill the gaps left by the presentations in order to address the initial planned agenda, and secondly to provide the symposium with an open forum that would allow participation by the audience and therefore interaction between the speakers at the table and potential authorities and other interested members of the conference.

The first round table was included in the programme as session III dealing with practical considerations about flying aptitude when metabolic disorders or cardiovascular risk factors are present in pilots. Six speakers addressed a short presentation of the following relevant topics: Relation between diet and coronary heart disease ; hyperlipidemia; hypertension; smoking habit ; diabetes mellitus; obesity and sedentary lifestyle - all topics as they apply to aviators.

Session V was a second round table in which different aspects of the influence of diet and lifestyle on aircrew performance were considered. Four speakers gave inputs about: Energy and nutrient requirements; catering facilities ; and special dietary considerations as they relate to cold and hot weather operations and to prevent jet-lag syndrome.

5. TECHNICAL EVALUATION

The keynotes of the symposium emphasize the importance of nutrition in the maintenance of health of aircrew contributing to improve physiological and psychological performance. A proper nutrition is important to prevent the appearance of metabolic disorders such as obesity, hyperlipidemia or diabetes, situations

which may produce an impairment of aircrew efficiency and sometimes result in pilot grounding. The different NATO country policies in relation to the metabolic disorders are presented according to a survey recently conducted among the different aviation medicine specialists. Other factors such as poor physical conditioning, cigarette smoking or sleep disturbances which may contribute in the long term to atherosclerosis and in the short term to fatigue and human error are also considered.

In Session I- DIETETICS AND NUTRITION APPLIED TO AIRCREW, chaired by Dr. Tangney and Dr. Alonso, paper 1 (Van Erp-Baart et al) describes a new automated processing system which permits the rapid assessment of dietary habits including quantitative food frequency and the food knowledge of individuals. The system includes a software for interactive data entry, checks, corrections and calculation procedures which can be adapted to the desired accuracy of the results of the questionnaire.

Paper 2 (Hart, Morrison) describes the dietary habits of 184 USAF TAC fighter pilots according to their age, family configuration and level of exercise. Pilots[2] energy consumption of 2.800 KCal is estimated suitable . The nutrient composition of their diets was 46 % carbohydrates, 34 % fats , 15 % proteins and 5 % alcohol, better than the mean U.S. dietary habits but still short of the U.S. Dietary Guidelines. Significant effect of exercise level was detected for weight and carbohydrates consumed. The authors also found age group differences in alcohol intake and fat consumption, the older group consuming less fat and more alcohol than the younger, suggesting that there is a need for dietary education and improving the availability of food choices.

The authors of paper 3 (Lovo et al) present the utilization of portable equipment developed to estimate the energy expenditure by continuously recording the body position and the heart rate.

The experiment uses the calculated energy intake to evaluate the energy expenditures, assuming that the body weight of the volunteers is unmodified. Validation experiments are required.

Two experiments are conducted in paper 4 (Guezennec et al) in order to establish the protein requirements in two situations. The first experiment examines rats after 21 days of hindlimb suspension to simulate prolonged weightlessness. The results indicate that a high protein intake (30%) may reduce muscle protein wasting when compared to normal protein intake (15%). The second experiment is conducted in humans submitted to repeated exercise in altitude hypoxia, on diets with two different protein contents, showing that the decrease in plasma concentration of branched-chain aminoacids observed in individuals taking normal amount of proteins was preserved in those on high protein intake.

Paper 5 (French et al) analyses the boxed in-flight meals used by US Military Airlift Command aircrew during the Desert Storm Operations in terms of energy, protein, carbohydrates, fat, cholesterol, saturated fat, sodium and potassium. The data obtained are compared to the Military Recommended Dietary Allowances and with the minimum adult daily requirement. It concludes by recommending the improvement of these meals which are the most important source of nutrition of the aircrew studied, together with keeping the base food service facilities open longer and improving the aircrew nutritional education.

Paper 6 (Helle et al) compares the results of a study conducted six years ago in which assessment of food intake,energy sources and spacing of the meals in a squadron located well north of the Arctic Circle with the findings of a similar study recently undertaken, in order to evaluate the effectiveness of the campaigns and courses aimed at improving dietary and lifestyle habits. The daily intake of energy (10 MJ), dietary fiber (18 g.) and the percentage of energy derived from proteins (17%) have not changed. The percentage of energy intake derived from carbohydrates has slightly increased (from 46 to 49%) unlike the fat which has diminished (from 35 to 33%). In the last survey a greater number of participants had three main meals per day. In general terms the diet of the aircrew is better than the average in Norway.

Paper 7 (Mendez, Peralba) studies the response of ten normal volunteers after seven days of having a commercial emergency ration as the only source of energy, through evaluation of anthropometric and metabolic parameters and considering the psycho-physical acceptability. The results are found to be satisfactory when it is used during short periods of time.

Col. Burgers and Col. Vandenbosch were the chairmen of session II- METABOLIC DISORDERS AND CARDIOVASCULAR RISK FACTORS IN AIRCREW. The session commenced with paper 8 (Farrace et al) ,the only work presented in the conference dealing with hypoglycemia a very important metabolic and operational aviation medicine problem. The authors found a reaction compatible with hypoglycemia (G<50 mg/dl) in 9 out of 120 young Italian Air Force cadets (Group A) who underwent a prolonged oral glucose tolerance test. The hypoglycemia was mainly found between minutes 195 and 225 of the test, presumably due to an increase of insulin levels in group A subjects together with a lack of glucagon response during the glycemic nadir. It concludes by recommending the preflight limitation of carbohydrate intake and the avoidance of those characterized by fast absorption.

The following papers: 9, 10, 11, 12, 13, 14, 16, 18 and 19 of session II consider the level of blood lipids associated to other cardiovascular risk factors or lifestyle habits in different NATO countries. Paper 9 (Seigneuric et al) presents a retrospective study (1980-1989) of the prevalence of hyperlipidemia in French Military Aircrew using age-related standards. It also considers the results of the treatment used and the effects on aircrew fitness.

Paper 10 (Palermos et al) reports a complete blood lipid profile in 324 healthy Hellenic Air Force ground active duty officers, randomly selected along 6 months. The study includes determination of total lipids, total cholesterol, HDL- cholesterol, LDL-cholesterol and apoproteins A1 and B. The population studied was divided into three groups of age. The results suggest that the blood lipid levels are higher than internationally recommended. Total lipids, total cholesterol, LDL-cholesterol and apo B are found elevated in age 36-40 when compared to age 31-35. This difference does not exist when compared to the older group, probably due to the awareness of the risk of hyperlipidemia.

Paper 11 (Hull) studies the cholesterol and triglycerides levels in RAF recruits for flying training and in trained RAF aircrew, finding a significantly lower mean cholesterol values in the first group (180 vs 213 mg/dl). The results of plasma cholesterol in trained aircrew, though lower than the average British population, were above of desirable limits and correlated with age, which in the author's opinion accounts for the difference found. In this sense abnormally high cholesterol levels were seen in 3% of the recruits and in 18% of the aircrew. It implies that selection at entry only slightly reduces the incidence of hypercholesterolemia. Better results are expected by intervention in order to modify the personal habits.

Paper 12 (Farrace et al) reports different lipid profiles in two matched populations of controls and pilots. Cholesterol and triglyceride concentrations and the mean arterial pressure are significantly lower in pilots than in controls and also when compared to the average italian population. Other cardiovascular risk factors such an increase of Lipoprotein (a) concentration and the decrease of the APO A/B ratio were more important in pilots than in controls suggesting a trend towards atherosclerosis.

Paper 13 (Gomez -Marino et al) reports the smoking habit as the most important single cardiovascular risk factor in 32 Spanish pilots with demonstrated coronary obstructive lesions by means of coronary angiography, unlike other studies in which hypercholesterolemia and hypertension are the most important cardiovascular risk factors. These results can be explained considering the very high number of cigarettes smoked by the spanish pilots as has been reported later in this session in paper 22 (Rios et al). Nevertheless, hypercholesterolemia and hypertension were not so important due to the aeromedical intervention at the periodical physical examinations.

Paper 14 (Rödig) describes an extensive survey conducted in 4.563 German pilots during 4 years. 37.2% of the total population studied presented plasma cholesterol levels above 220 mg/dl, while 25.1% had a total cholesterol/HDL-cholesterol ratio over 6. This percentage goes up to 52.4% in pilots older than 41 years. The paper consider other cardiovascular risk factors and the introduction of a dietary and physical fitness programme devoted to improve the present results. The aeromedical exams have to address the early detection of silent cardiac ischemia.

Paper 15 (Braz de Oliveira et al) makes a 10 years follow-up of a group of 50 Portuguese Air Force pilots recruited from volunteers with a non AF Academy background evaluating the incidence of smoking habit and alcohol abuse, body weight and blood pressure, taking into account the influence of the psychological background. Among the results it is of interest to mention that 36% of the population studied smoked over 20 cigarettes per day and only 10% were non-smokers and also that 56% were overweight with 28% exceeding by more than 10 kg. their ideal body weight. The authors consider the lack of motivation and the psychological background as partially responsible for these findings. They recommended an improvement in the social environment and correction of the existing gap with other portuguese pilots.

Paper 16 (Daskalopoulos et al) relates some biochemical parameters (glucose, total cholesterol, HDL-cholesterol, triglycerides, uric acid and GGT) with some lifestyle variables (dietary intake, physical exercise and anthropometric) in both one group of 157 Greek military pilots and another group of the

same number of airline pilots. The results obtained permit the authors to recommend to both military and civil pilots: 1) To reduce the levels of plasma cholesterol, 2) To increase the physical activity, and 3) To have more meals per day with less energy and fat and with more complex carbohydrates.

Paper 17 (Cook et al) provides a baseline of lifestyle habits based on the data of a survey conducted in 82 pilots of the USAF Air Training Command, Randolph AFB. The paper gives information about dietary intake, including a 24 hour dietary recall, exercise, smoking, caffeine and alcohol intake and work schedules. Among the results is of interest to remark the fact that 93% of the subjects claimed to know their plasma cholesterol level and the same high percentage were nonsmokers. Another interesting point is that 85% of the pilots reported skipping meals due to the flying schedules.

Paper 18 (García Alcon et al) studies the influence of diet and physical training on body weight and plasma lipid levels in 230 Spanish Air Force pilots, throughout one year. The population was divided into three homogeneous groups: Group A) Free diet and free exercise, Group B) Controlled diet and free exercise and Group C) Controlled diet and controlled exercise. Group A showed a progressive increase of total cholesterol, LDL-cholesterol and triglycerides together with the TC/HDL-C ratio secondary to an HDL progressive decrease. On the other hand Groups B and C with controlled diet did not present significant changes in blood lipid levels along the three different controls conducted throughout the year. The evolution of the HDL-cholesterol plasma levels in Group B was similar to Group A and in both different from Group C in which no significant variation was detected.

Paper 19 (Tuomala et al) reports the poor influence of dietary counseling and cardiac catheterization on lipid profiles in a study conducted in 109 USAF and US Army aviators from 1986 to 1991. The pilots studied were asymptomatic and cardiac catheterization was

study were subdivided into three groups based on the cath findings: Normal; Minimal coronary artery disease; and Intermediate and severe coronary artery disease. When each group was compared to their matched controls who did not have dietary counseling nor cardiac cath, no significant changes in lipid values were found. Nevertheless both groups showed a trend towards improvement.

Paper 20 (Vastesaeger and Vandenbosch) presents a 45 year follow-up study of the evolution of biological parameters and cardiovascular risk factors of all pilots and navigators of the Belgian Forces. Most of the parameters checked did not change except the body weight and the blood pressure which, as expected, are progressively increasing. The smoking habit has diminished except for heavy smokers who persevered. In spite of the fact that there are a number of individuals exceeding the normal upper limit of triglycerides and cholesterol, the overall results demonstrated a good quality of selection and care, although the potential for further improvement existed. Another similar study is presented in paper 21 (Neslein et al) in a group of 38 fighter pilots from the Royal Norwegian Air Force in which a series of biological and biochemical parameters are determined at selection, after 6 years of service and after 12 years. Both body weight and plasma cholesterol levels were increasing along the years of the study. During the first six years the oxygen uptake was stable indicating that the weight-increase is probably fat induced. Dietary and lifestyle habits are responsible for the variations of biochemical parameters found.

Paper 22 (Rios et al) is the only paper of the conference dealing specifically with the smoking habit. It points out that cigarette smoking is a well known cause of major illnesses which can impair pilot performance and even result in temporary or permanent flying disqualification. The study conducted among military pilots of the Spanish Air Force demonstrate a significant decrease of tobacco use, directly related to the antismoking efforts of the aeromedical community. It considers the

history or elevation of nicotine catabolite.

Session III is a round table chaired by Col. Vandenbosch where the presence of the major metabolic disorders and cardiovascular risk factors in aviators is considered from the point of view of the aeromedical implications. The existence of hyperlipidemia, hypertension, diabetes mellitus (DM) and obesity in pilots is analyzed, together with cigarette smoking. Session III has been included in the programme as paper 23.

Dr. Vandenbosch (BE) recalled that although the mortality due to atherosclerosis has strongly diminished in some countries during the last decade, coronary artery disease (CAD) is still the major cause of death in western industrialized nations.

The composition of diet and especially the relation between the saturated and the unsaturated fat strongly influence the plasma cholesterol values as has been shown in the Seven Countries Study and in other studies. There is no precise threshold value for high cholesterol and the relationship between plasma cholesterol and CAD is also applicable for both low and high cholesterol levels. The presence of high levels of plasma triglycerides which has been considered a doubtful or secondary cardiovascular risk factor may be relevant, especially when combined with low HDL-C levels.

Dr. Vandenbosch finally stressed the importance of the "high risk strategy", in addition to the "population strategy". It focuses its attention in individuals with significantly increased risk of CAD, including evaluation and intervention by means of diet or medical treatment when necessary.

The session chairman passed the podium to Dr Rödig (GE) who further addressed the topic of hyperlipidemia. He considered the changes of eating and drinking habits as one of the more important factors responsible for the development of CAD. He presented some figures concerning the increasing fat consumption in GE . The consumption of

have increased manyfold in the last four decades in GE. These dietary changes may partially account for the high incidence of risk factors in the german population. This is especially true in men , 15.9 % of whom are diagnosed with arterial hypertension, 29 % with plasma HDL-C levels below 35 mg/dl and a similar percentage with total cholesterol over 260 mg/dl. On the other hand improving the dietary habits may produce an impressive lowering of the incidence of CAD best illustrated by the US experience in which the mortality rate for CAD has been reduced by more than 25% from 1977 to 1986 due in large part to the National Cholesterol Education Program (NCEP).

Dr. Rödig also considered the possibility of using the new drugs inhibiting the cholesterol synthesis (HMCoA reductase inhibitors) in pilots with hypercholesterolemia resistant to non pharmacological measures. Some of these drugs such as lovastatin and symvastatin may affect the central nervous system, producing sleep disruption and impairment in day time alertness and performance. Pravastatin, on the other hand, is more hydrophilic and shows more affinity for the liver, and due to the lack of evident central effects, should be considered as one of the drugs of choice in pilots.

Finally, Dr. Rödig reviewed the diversity of the different NATO country policies regarding the levels of plasma lipids, proposing to reach an agreement among the nations by achieving an harmonization of the limits permitted at the physical examination of the aircrew.

Dr. Celio (US) said that hypertension is a well established major modifiable risk factor for coronary, cerebral and renovascular disease. The prevalence rate in the US according to the 1.984 Joint National Committee on Hypertension range between 9.2 % in the 18-20 year old age group and 62.3 % in those 65-75 year of age. This prevalence rate is based on a single individual pressure reading and it can be overestimated by as much as one third. Hypertension frequently coexists with other cardiovascular risk factors . When associated with hyperlipidemia the risk is increased in

In a large epidemiological study, prolonged increase in diastolic blood pressure of 5 and 10 mmHg was associated with a 21% and 37% increase in CAD and with 45% and 56% in stroke risk, respectively. Adequate treatment of hypertension can reduce this increased risk. In patients with well controlled arterial hypertension the overall mortality rate may decrease in 20% with a diminution of more than 45% reduction in deaths secondary to cerebrovascular disease or myocardial infarction.

In Dr. Celio's opinion, hypertension should be a cause for grounding when the blood pressure can not be controlled with aeromedical acceptable therapy, which involves salt restriction and diet. The use of certain medication should be limited to drugs with minimal side effects and not producing any performance degradation of the pilot, since the treatment of this disorder should not increase occupational risk. If the pilot requires some medication which may compromise performance or flight safety then he should be grounded.

Dr. Rios (SP) recalled the fact that in most of the NATO countries the percentage of smokers is over 30%, only the US showing figures far less than the average, in most instances reflecting what is happening in the normal population.

Smoking has been widely recognized as a major aviation related problem. The habit can affect multiple systems especially respiratory and cardiovascular. Dr. Rios suggested three main implications :

1) Aeromedical: The smoking derived pathology may lead to:
a) Acute impairment: Neumothorax; Flight inhalants; Sudden death.
b) Chronic diseases:
Immunosuppression/Cancer; Impairment of the dark adaptation; Major cardiovascular risk; chronic obstructive pulmonary disease.

2) Economical: Smoking habit is a well known cause of minor and major illnesses than can result in temporary or permanent disqualification of the aircrew.

3) Operational: Smoking may result in impairment of G tolerance. Neuromuscular coordination during nicotine withdrawal could be affected.

Smoking in aircraft was examined from the points of view of the health aspects and the flight safety. Dr. Rios presented the regulations regarding smoking policy in the NATO countries major airlines.

I reported that diabetes mellitus is a common clinical problem which also affects the flying population. This condition may appear along the pilot career and is difficult to prevent it at the initial physical examination. In this sense some of the air force and airline carrier medical services have conducted an oral glucose tolerance test (OGTT) in every applicant, ruling out those presenting a pathological response. This position is not universally accepted because individuals showing an abnormal OGTT may not develop DM. On the other hand there are pilots starting with diabetes who presented normal OGTT years before. In this regard it was pointed out that the criteria for OGTT interpretation used before 1.979 were not specific enough to be predictive. Present criteria for diagnosis based on OGTT are that non-insulin dependent DM (NIDDM)is confirmed if the 2-hour value is above 200 mg/dl and one other value is also greater than 200 mg/dl. In addition when random serum glucose is over 200 mg/dl or fasting plasma glucose is more than 140 mg/dl the patient is considered diabetic.

It was mentioned that due to the lack of any significant data with regards to relation of family history of diabetes to the ultimate development of the disease in an individual, this potential risk factor is not important to be considered when selecting a pilot applicant.

The position of every NATO nation concerning type I DM is logical and clear grounding all the pilots and aircrew due to the high risk of insulin hypoglycemia. This agreement does not exist concerning the NIDDM (type II), which is the most frequent

form, accounting for at least eighty-five percent of all patients with DM, and more in the flying community. When DM type II is detected in one experienced pilot, as usually happens because its prevalence increases with age, most of the NATO nations permit the pilot to continue the flight activities when the DM can be controlled by means of exercise and diet. France and Belgium permit pilots to flight when they can control the DM with biguanides. These drugs do not offer risk of hypoglycemic reactions but they may produce other undesirable side effects especially gastrointestinal and lactic acidosis which have to be individually evaluated before permitting return to flying duty. Sulphonylureas are not recommended because of their potential risk of hypoglycemia

Dr. Schwender (US) discussed two additional cardiovascular risk factors closely interrelated, obesity and sedentary behavior with regard to pilots and whether these conditions could be reasons for medically grounding a pilot. For Dr. Schwender, medical grounding is often based on an assessment that an unacceptable risk exists for sudden incapacitation during flight, or may be based on an estimated decrease of performance below an equally undefined threshold which would result in failure of the mission.
He considered that there is a genetic predisposition in some individuals, having preferred metabolic pathways and basal metabolic rates which tend to make them obese when consuming the same diet as other subjects who have normal or thin body habitus. Dr Schwender defined the obesity as the state when the individual is greater than 20% over his/her ideal weight secondary to excess fat. Sedentary behavior describes only non-regular physical activity and is not the absence of a vigorous aerobic fitness program.

Dr Schwender said that obesity and sedentary behavior are easily observable conditions which are markers for CAD. In a pilot the presence of these conditions should make you more suspicious of the possible presence of this often silent but potentially catastrophic disease.

Sedentary behavior has been confirmed as an independent risk factor for CAD with a power equal to about one pack per day of smoking. The beneficial effects of regular exercise has been proven in those men who did have the misfortune to suffer a myocardial infarction, these who were regular exercisers had a higher survival rate. This is probably due to the appearance of collateral circulation in addition to the other beneficial effects of aerobic exercise to include: increased cardiac stroke volume, a higher threshold for ventricular fibrillation, reduced pulse rate, decreased peripheral resistance and increased plasma levels of HDL-cholesterol.

Dr Schwender said that it would be controversial to suggest the medical grounding of a pilot for simply being obese. In his opinion, a pilot who is unable to safely enter or exit their aircrew station, exceeds the capacity of an ejection seat, or can not fully operate all the controls and switches, it is an operational problem to be dealt with the squadron commander, director of flying operations and wing commander chain of authority. If the pilot is a non-exerciser the issue is also operational. These considerations are made under the USAF point of view where there is a weight and physical fitness regulation which is independent from its medical standard regulation. USAF pilots must meet the same weight and fitness standards as all other Air Force members. This may not be true or as vigorously enforced in other NATO forces.

There was an interesting debate at the end of the session and it is of interest to mention the GE policy on hypercholesterolemia explained by Dr. Rödig in response to Dr. Celio. In GE Air Force the desirable cholesterol levels are under 200 mg/dl. When they are between 200 and 250 mg/dl, they do assessment of other risk factors and when they are present, other cholesterol fractions are measured, looking for possible CAD. Following the recommendations of the National Cholesterol Initiative (Prof. Assman) and of the European Atherosclerosis Society, GE has obtained good results in prevention of hypertension and maintenance of fitness but not in hypercholesterolemia.

Dr. Celio asked Dr. Rödig if the GEAF had a policy of secondary screening in individuals with identified elevated risk factors such as treadmill test. Dr. Rödig said that every german pilot undergoes a medical examination every year. Before 40 years of age they have to go every three years to the Institute of Aviation Medicine, and then every year. In these exams, a treadmill ECG test is conducted and they have to reach at least a performance of 2.1 watt/kg of body weight related to a heart rate of 170 beats per minute. Lately the GEAF is considering a maximum performance capacity exercise test screening for possible signs of CAD.

A third question to Dr. Rödig was about the indication for invasive techniques to assess for the presence of atherosclerosis when ST segment abnormalities were found in the exercise test in aviators. He answered that when a german pilot had combined cardiovascular risk factors with an abnormal exercise ECG, the pilot is referred for coronary artery catheterization without any previous cardiac scan. This is because of the frequent false negative results of this last technique, felt to be due to the collateral circulation with acceptable perfusion seen in most of the german pilots with a good physical fitness

The discussion, open to the floor after completion of these round table presentations, found some level of disagreement regarding the proper action to take in an experienced aviator who develops diabetes mellitus. This was primarily rooted in a concern regarding the high cost of properly replacing that experienced pilot.

While I understood the reasoning behind trying to keep an experienced aviator flying in spite of the need for insulin, I expressed that most endocrinologists would agree that risk of hypoglycemia, possibly occult, even in a very well controlled diabetic, would be prohibitive whether on insulin or on sulphonylurea therapy. Biguanides, on the other hand, because they do not cause hypoglycemia, would be acceptable after a short trial to ensure no side effects. Unfortunately this class of drugs is rarely effective.

Dr. Santucci (FR) raised the issue that although cardiac disease has been discussed in length, in his country's experience, there were actually no proven aircraft mishaps due to an acute cardiovascular or pulmonary event. In fact several members of the panel and the audience responded that several cases have been documented of acute pilot incapacitation as a result of cardiopulmonary disease immediately before, during (when in a two pilot aircraft), and after a flight. Dr. Celio (US) added that many aircraft accidents currently attributed to "human factors" were in fact likely secondary to acute cardiopulmonary events but were impossible to prove due to the condition of the remains. One of the final comments in the discussion was actually a recommendation that the available data should be used by all NATO aeromedical specialists to produce common guidelines dealing with each cardiovascular risk factor. Of course, because of varying applicant pools among the NATO nations, the degree of acceptance of certain risk factors must also vary. Universal guidelines could be utilized to form a stratified risk assessment index which could then be applied to the flying community in order to identify the specific subpopulation at highest risk. This group could be submitted for secondary screening.

In session IV- AIRCREW LIFESTYLE AND PERFORMANCE chaired by Dr. Schwender and Dr. Burgers, paper 24 (Salter et al) is an interesting experiment directed to assess the effectiveness of an anti-jet lag diet prescribed by Charles Ehret, consisting of daily systematic alternating of high calorie and low calorie diet with high protein breakfast and lunches together with high carbohydrate dinners. Jet lag syndrome was experienced with similar severity by individuals on the anti-jet lag diet and by the control individuals. The anti-jet lag diet group slept on average 30 minutes less and were 31% less efficient than controls, indicating that anti-jet lag diets are not effective and may even worsen the jet lag symptoms.

Paper 25 (French et al) studies the flight safety repercussion of C-141 crews exceeding the maximum 30-day cumulative flight hour

limit of 125 hours. The combination of cumulative flight hours per month with increasing hours of recent flight revealed significantly increased fatigue and diminished vigor. The association of cumulative flight hours per month with decreasing hours of recent sleep affected a wide complex of subjective states (anger, depression, confusion, vigor, fatigue and tension). The authors conclude that attending to recent flight and sleep histories is possible to reduce fatigue and to improve mood when operational pressures require exceeding 125 flight hours per month. The same group of authors (Boll et al) belonging to the Sustained Operations Branch of the Armstrong Laboratory present paper 26, a study of the C-141 aircrew sleep and fatigue during the Persian Gulf conflict. Fatigue increases as the average duty day increases but less so if the duration of the recovery crew rest is also increased. They propose better crew rest period arrangements resulting in less time to fall sleep and less fragmented sleep.

The effects of cockpit heat on aviator sleep parameters is the title of paper 26 (Caldwell et al). The experiment is conducted with US Army aviators flying an UH-60 simulator wearing an NBC IPE in temperatures of 35°C and 41°C. Normal sleep patterns were altered during the first half of the night when core body temperature increased during flight more than 1°C, the first slow wave sleep (SWS) period being longer and the first rapid eye movement (REM) period becoming shorter. These findings suggest that aviators flying in hot environments may require longer sleep periods than normal in order to reduce subsequent fatigue.

Paper 28 (Cabon et al) emphasizes the importance of managing the sleep periods in order to increase the flight safety. This is especially relevant today due to the important automatization of the cockpits and the increasing autonomy of the airplanes with considerably longer flying times forcing consideration of the sleep-wake cycles. The influence of the pilot shifting time tables with frequent night flights and the additional jet lag syndrome causes physiological alterations which affect the sleep-wake rhythm and the pilot performance. This, in turn impairs awareness during the current flying activity. The paper proposes short sleep periods at the proper time which may reduce fatigue and drowsiness due to the sleep deprivation and also considers the minimum time required to elapse between the end of the nap and the return to the operational activity.

Paper 29 (Bisson et al) reports the use of Digital Flight Data Recorders (DFDR) to assess fatigue-related changes in pilot performance during continuous air operations. Five C-141 crews accumulated 150 hours in less than 30 days after cessation of Gulf War. DFDR were utilized to evaluate a possible correlation between various fatigue estimates, such as flight deck observations, activity logs, subjective fatigue ratings, oral temperature and profile of mood, and the pilot ability to fly precision approaches. Grouped performance abilities did not correlate with cumulative flight hours but the analysis demonstrated individual examples of decreased precision related to fatigue, pilot experience, meteorological factors and time of the day.

The effects of caffeine on mental performance and mood in aircrew members is the subject of paper 30 (Lieberman et al) in which in a series of double-blind, placebo controlled studies are conducted in order to examine the acute effects of caffeine on reaction time, vigilance, cognitive performance, memory and mood state. Doses equal to single servings of beverages improved auditory and visual vigilance and lowered reaction time. Moderate doses of caffeine improved mood state. The duration and magnitude of the effects were related to the usual caffeine consumption and interacted with tobacco use and personality factors. The authors also consider the consequences of abrupt withdrawal.

Session V was a second round table permitting an open discussion, including briefings on: Aircrew diet in terms of energy and nutrient requirement, aircrew catering facilities, jet-lag preventing diet, diet in hot and cold weather operations.

I acted as a chairman and I addressed some comments about the aircrew diet in terms of energy and nutrient requirements. The accepted dietary guidelines were basically applicable to pilots and other aircrew and they are: 1) Total calories supplied should be adequate to achieve and maintain the body weight close to the ideal value. 2) Carbohydrate intake should not be less than 50% of the total calories with preference of complex carbohydrate and fiber, limiting the amount of sugar. 3) Protein intake has to be approximately 15% of the total calories. 4) Lipid intake has to be less than 30% with saturated fat less than 10% and cholesterol less than 300 mg per day. 5) Sodium intake reduced to less than 3 g. per day.

To estimate the energy requirement is necessary to take into account other factors apart from the body weight such as activity, gender, age, environmental temperature, altitude, muscle mass and even psychological factors.

Although the World Health Organization in the past has classified various professions with regards to their likely daily energy requirement, I have found no specific references that do the same considering the different types of flying activities. We may presume that non-fighter pilots as well as air traffic controllers develop during the missions a mild intensity activity (2000-2800 Kilocalories per day in an standard subject). In many cases for an important period of duty time they are doing administrative business. Fighter pilots and paratroops are more intense energy demanding, not only for the activity performed during the missions but for the physical training that they have to do to accomplish them. Some aircrew will obviously encounter short periods of very intense activity, but this generally lasts for only a few minutes of each mission and is the exception rather than the rule.

To determine the energy requirement of one pilot based on his activity we have to consider not only the energy expenditure when he is on duty but also during the rest of the day. Dietary requirements, even during duty hours, can vary with the amount of activity undertaken. If we accept the premise that all aircrew members perform daily exercise in order to maintain appropriate weight and to avoid the maladies associated with obesity and inactivity, then we must consider the additional burden of these required work places on the dietary strategy. In order to accomplish this, very often it is convenient to modify both the dietary frequency and the amount of caloric intake.

The next speaker was Captain Cook a registered dietician from Armstrong Laboratory in Brooks AFB (US). She considered that many of the menu planning in the past were directed by the aviator preferences, with little nutritional concerns. Unfortunately this often led to poor dietary choices (high fat, high cholesterol, high sugar).

She emphasized the US dietary guidelines, as mentioned before, adding that polyunsaturated fat should be up to 10% and the monounsaturated fat between 10 and 15%.

In the recent past, the old four groups of food (grain, meat, milk and vegetable-fruits) were equally recommended. Now a new model has been developed giving more emphasis to bread, cereal, rice and pasta (6 to 11 servings), followed by vegetables (3 to 5 servings) and fruits (2 to 4 servings), and by the group of meat, fish and eggs and the group of dairy products (2 to 3 servings of each). The catering facilities should adhere to these dietary guidelines to meet the pilots needs. This diet, built around the complex carbohydrates, also is high in fiber. However a lot of pilots have been told in the past to decrease the amount of fiber intake by decreasing the gas forming foods. Thus it is advisable to introduce these changes gradually increasing the amount of fiber to 25-30 grams per day.

Traditional recommendations have been that the preflight meals should be nutritious and easily digestible. Breakfast and other major meals should not be omitted. The crews should be allotted sufficient time to eat the meals. It is advisable to avoid fatty foods, alcohol, and overeating. Nevertheless very little research has been done to support these recommendations.

The in-flight meals in the USAF are dictated by regulations. Sometimes the aircrews do not know the type of mission they are going to fly and consequently the catering facilities do not meet the needs. On the other hand the worldwide menus are based on groundcrews rather than aircrew which as mentioned tend to be more sedentary and less energy demanding. In this regard the "slim menu" has been introduced to provide about 1.500 calories a day for aircrews which require reduction in calories.

Dr. Salter reviewed some of the important points made in his earlier presentation regarding the anti jet-lag diet. Specifically, he utilized Dr. Liberman's data demonstrating the strong effects of caffeine, even in small doses, in supporting his contention that the caffeine portion of Dr. Ehret's diet was almost surely the culprit in the failure of this regimen in the only actual test of the full diet in human subjects. However, he felt that there were hints in the literature that the other components of Dr. Ehret's proposed diet were in fact, beneficial via their effects on central nervous system tyrosine and serotonin levels. Thus, he suggested future studies of the diet without the caffeine component.

Captain Cook (US) again took the podium for a brief discussion of dietary needs for hot weather conditions. She pointed to the recent experience in the Persian Gulf, emphasizing the importance of adequate hydration. A potential hazard in this situation is the utilization by aircrew of caffeine containing beverages as their primary source of liquid replenishment. This concern, of course, was because of the diuretic effects. Another important issue that was raised was the need for dieticians to plan menus with foods requiring no refrigeration in an effort to minimize the risk of food-borne illness which, if causing diarrhea, would clearly potentiate dehydration.

Dr. Holm (NO) told us of two norwegian North Pole expeditions that utilized a practical dietary ration specifically designed to provide maximum calories combined with mass and easy preparation. This high fat mixture ensured enough energy to maintain the intense activity that was required to accomplish daily tasks while maintaining adequate body temperature. Although admittedly not palatable, the norwegian expedition members were able to survive and function for 2-3 months in the Arctic environment with this specialized ration as the only source of nutrition.

Most of the discussion about these round table presentations centered on one main point: How to influence aircrew in changing their diet to adhere to the above described dietary principles. Two methods were suggested. The first step should be to provide in-flight meals that fulfilled dietary recommendations and were palatable enough to discourage additional less nutritious snacks. Irradiation of "healthy" foodstuff that in the past could not be maintained on long flights may give us a way of better meeting these needs. The second step in improving the diet of aviators is simply to assure the ready availability of healthy choices in local dining facilities. This could be best accomplished by emphasizing the roles of dieticians and flight surgeons in reviewing and approving local menus.

6. CONCLUSIONS

6.1. The diet of NATO aircrew tend to reflect the dietary habits of the civil population in each individual country. However some air forces have made positive strides in improving their diet relative to the general community. Unfortunately, even in these best examples, the diet continues to fall short of the International Dietary Guidelines.

6.2. Special operational conditions exist that may require modification of the accepted International Dietary Guidelines. These include extremes in environmental temperature, the microgravity environment, severe time zone shifts, extended duty time and emergency situations.

6.3. It is now universally accepted that the major cardiovascular risk factors are: hypercholesterolemia, hypertension and cigarette smoking. Other important risk factors include: diabetes mellitus, obesity, sedentary behavior and stress. The end result of one or a

combination of any of these risk factors over time is the development of cardiovascular disease which often directly impacts the flying mission through decreasing the length of the career of experienced aviators and in directly causing aircraft mishaps due to acute cardiovascular incidents.

6.4. A high incidence of hyperlipidemia in the aircrews has been reported by almost all of the NATO nations. •

6.5. One NATO nation has described a significant improvement in the degree and incidence of hyperlipidemia in the general population and hence a reduction in the morbidity and mortality due to cardiovascular disease. This was the direct result of an extensive programme aimed at educating the public and at modifying their diet.

6.6. Cigarette smoking is unfortunately very common in the vast majority of NATO air forces. It is a problematic habit in that it produces both short term and long term consequences. These consequences result in a reduction in efficiency and a greater risk of inflight incidents.

6.7. It is agreed that a pilot who develops diabetes mellitus will be permitted to continue flying only if the metabolic disorder can be controlled by diet and exercise alone. Because of the risk of hypoglycemia pilots on insulin or sulphonylurea therapy should not be given primary flying responsibility.

6.8. Aircrew fatigue seems to result in a measurable reduction in pilot skills such that precision landing of aircraft is affected.

6.9 The most popular anti jet-lag preventing diet has been demonstrated not to be beneficial because of the caffeine adverse effects.

7. RECOMMENDATIONS

7.1. The International Dietary Guidelines are basically applicable to aircrew. These principles are: 1) Total energy supplied should be adequate to achieve and maintain the body weight close to the ideal value;

2) Carbohydrate intake should be at least 50% of total calories with preference of complex carbohydrates and fiber; 3) Protein should make up approximately 15% of total caloric intake; 4) Total fat intake should comprise less than 30% with saturated fat less than 10% and cholesterol less than 300 mg. per day; 5) The sodium intake has to be limited to a maximum of 3 g. per day. Strategy should be designed to ensure that NATO aircrew adhere as closely as possible to these recommendations.

7.2. The best method of assuring compliance with dietary goals would be to involve flight surgeons and dieticians in the planning and elaboration of both in-flight menus and in choices offered at local dining facilities

7.3. Further studies should be conducted regarding the need for dietary modification under special operational conditions such as extremes in environmental temperature, space operations, jet-lag syndrome prevention and emergency situations.

7.4. An effort must be made to continually improve the ease of data collection regarding diet and nutrition as well as to update the validity of the data itself, utilizing new methods of garnering this knowledge.

7.5. The high incidence of hyperlipidemia among the NATO aircrews has to be diminished. Intervention can be best be achieved through the formulation and application of a wide ranging strategy of education, motivation and dietary modification, modelled after other programmes that have proven successful in civilian population.

7.6. A strong anti-smoking policy should be assumed by all NATO air forces. This should especially be applied to aircrew members.

7.7. Although utilized in some civilian aviation sectors, the oral glucose tolerance test probably does not provide an adequate screening test for the potential of developing diabetes mellitus at a later time. Therefore this test is not recommended for routine use in this manner.

7.8. Based on currently accepted standards it should be mandated that a basic level of fitness be maintained by all aircrew on active flying status. The amount of exercise necessary to achieve this goal will vary among individuals.

7.9. High frequency or long duration missions should result in special attention being given to adequate and meaningful crew rest, possibly greater than the usual amount of time allowed in normal operational situations.

7.10. Although the anti jet-lag diet as it is currently prescribed has being proven unsuccessful secondary to the caffeine component. Other data suggest that the nutritional manipulation recommended in this diet may hold promise in lessening jet-lag. Therefore is strongly recommended further investigation be conducted.

ACKNOWLEDGMENT:

KEYNOTE ADDRESS

NUTRITION, METABOLIC DISORDERS AND LIFESTYLE OF AIRCREW IN DIFFERENT NATO COUNTRIES

by

Major César Alonso Rodríguez SAF
Centro de Instrucción de Medicina Aeroespacial
C. Arturo Soria 82
28027 Madrid
Spain

The AMP focuses its goals on the study of the human being, unlike the other AGARD Panels that are devoted to different aspects of the aircraft. From the two components of the binomium man-machine that integrates the air weapon system, the members of this panel assume that the human factor is the most important one, due to the fact that he is responsible for the commands that have to be given to operate the aircraft. Man has been considered as the " weak link" in the man-machine system (Hickman et al 1.980) primarily due to the physiological limitations of adapting to the flight environment. In support of this statement, most of the surveys consider that in aircraft mishaps the human factor is responsible,in some way, in around 80 % of the cases. From these considerations we can assume that improving the health of the aircrew is an important way to increase the mission efficiency and flight safety.

The appearance of human diseases and the maintenance of health are closely related to three major factors: Genetics, environment and nutrition.

Genetics is an unmodifiable factor in the adult. In aviation medicine the only way to prevent the appearance of inherited diseases is during the initial physical examination of aircrew candidates. This includes a detailed family history, which can be a cause for rejection of the examinee should the individual run a great risk of developing a disease which may compromise mission eficiency or flight safety.

The environment, although it is responsible for multiple diseases is susceptible to modification in some aspects. For instance the incidence of infectious diseases, that are the principal cause of death in some developing countries, can be reduced by acting at different levels on the epidemiological sequence of transmission. This consideration is not valid for aerospace medicine in which unlike other branches of the medical science, the users of this discipline are exposed during their missions to unusual environmental factors such as low pressures, hypoxia, desorientation, noise ,vibration, different time shifts and extreme temperatures. These unusual environmental factors, frecuent'y in military aviation medicine, become hostile or even life threatening such as in exposure to long duration accelerations,rapid decompressions, space operations or exposure to NBC agents. The maintenance and improvement of the aviators health can not be done through the modification of the above mentioned environmental factors, and only through means of aircrew training and familiarization we can provide knowledge and awareness, thus providing the necessary protection.

Nutrition is an important way to improve the health of individuals. The term nutrition includes the sequence of processes by which the body receives, transforms and utilizes the chemical substances of food in order to maintain the body functions and to repair the physiological losses produced as consequence of the activity of the different body systems.

Nutrition of the individual depends closely on the diet, which is the way of providing the different types of nutrients to the body, as consequence of a series of conscious and voluntary actions directed to select and modify the available foods.

There is evidence that good nutrition improves the physiological and psychological performance of the individual. Dietary advice is considered of great importance not only because of the short term benefits, but also in the long run, as it has been shown that bad dietary habits over a maintained period of time contributes to fatigue and impaires performance, increasing the possibilities of human error. Another important reason to give dietary advice is due to the close relation existing between some dietary habits and certain metabolic disorders such as diabetes, hyperlipidemia or hyperuricemia. Some clinical conditions also depend on a great extent on the diet, as it happens with obesity, hypertension ,

coronary artery disease and cancer, which are among the major causes of death in developed countries. These conditions are also present in the flying community and may be responsible for the impairment of mission efficiency, for temporary aircrew groundings and for the shortening of the expected duration of the flying career.

It is not posible to ignore the importance of the diet when thinking of the cardiovascular system of the pilot which is at present, one of the major concerns of the flight surgeon. Pilots of high performance aircraft have to expose themselves to a high and sustained G environment during their missions. This implies constant blood shifting as a consequence of the changes in blood pressure in the different parts of the body, depending on the direction and intensity of the G forces. The relatively short experience with this type of stress and the fact that no other human activity submits the cardiovascular system to such severe changes is the reason for which the possible long term adverse effects are unknown.

The use of positive pressure breathing systems for increasing the human tolerance to the sustained G has become accepted as beneficial in terms of prevention of fatigue produced for the exposure to long duration accelerations, and several major Air Forces are incorporating these systems into the current pilot personal equipment. However the use of these systems , may impose a cardiac surcharge at the right ventricle with the possibility of the appearence of adverse effects after a number of years of use.

The aeromedical community is aware of the importance of the cardiovascular health of the pilot and in this way an increasing number of cardiovascular tests are incorporated to the practice of the initial and periodical physical examinations of the fighter pilots

The AMP is also concerned about the potential cardiovascular risks of the fighter pilots. To investigate along this line, it has undertaken different studies on echocardiography in pilots throughtout the Working Group 13 and lately Working Group 18. The AMP has also sponsored the "Cardiopulmonary aspects of aerospace medicine" short course which included considerations about different aspects of diet, metabolic disorders and aircrew lifestyle as coronary risk factors (Hickman 1.987)

Regarding aircrew cardiovascular health, the diet plays a central role among the other various coronary heart disease (CHD) risk factors (table 1) in the genesis of atherosclerosis. These include lifestyle risk factors such as cigarrette smoking, stress, and sedentary behavior. These factors interact among each other. Experimental studies have shown correlation between cholesterol-rich diet and atherosclerosis (Anitschkow 1.988, St Clair 1.983) . Studies in humans have also demonstrated a direct

relationship between the ingestion of saturated fat and the plasma total cholesterol levels which also correlated with the coronary heart disease morbidity and mortality. A great deal of the present knowledge about the association between cholesterol and CHD derives from major epidemiological, clinical and intervention studies including the -Seven Countries Study- (Keys 1.980), the -International Atherosclerosis Project- (Mc Gill 1.968), the -Framingham Study- (Anderson et al. 1.987), and the -Multiple Risk Factor Intervention Trial- (Stamler et al. 1.986). . Most of these surveys were conducted before the introduction of the mesurement of low-density lipoprotein cholesterol (LDL-c) and high-density lipoprotein cholesterol (HDL-c) in the current screenings. However, much useful information was obtained from these studies due to the fact that total cholesterol provides a reasonable approximation to LDL-c when exploring the relationship between LDL-c and CHD, as it has been proven in more recent observations (Rossouw & Rifkind B M 1.990).

There is a strong epidemiological and clinical evidence that HDL-c, unlike LDL-c, plays an protective role against atherosclerosis (Miller 1.987) as it has been demonstrated in multiple surveys such as the Oslo Heart Study in which a negative correlation was found between the HDL-c levels during life and the severity of coronary atherosclerosis at autopsy (Holme et al 1.981). This HDL-c protective effect has been demonstrated in arteriography studies conducted in aviators at the USAFSAM (Uhl et al. 1.981). Consequently it seems to be of most interest to introduce the mesurement of this cholesterol fraction, even in individuals with normal levels of total cholesterol. This consideration has been assumed by most of the NATO nations which have introduced the control of these parameters in their crews (table 2), as we understand based on a recent survey of the policies followed concerning the topics of this meeting, although the periodicity of these exams differs among them (table 3), as well as the interpretation of the results (table 4) and the policy with the aircrew presenting alteration of the biochemical parameters when giving the flying aptitude (table 5)

The adult onset diabetes mellitus is another diet influenceable atherosclerosis risk factor that has to be considered due to its aeromedical implications and the important incidence that affects also to the flying community. This condition is handled in different ways by the NATO countries as is shown in table 6 of the survey.

Obesity and sedentariness are closely interrelated. Obesity is produced by an imbalance between energy intake and energy expenditure resulting in adverse effects on health (Van Itallie 1979) which particularly affects aircrew normal activities. Regular physical exercise has a protective effect against

atherosclerosis in addition to other benefitial actions such as reduction of the overweight, diminution of emotional tension and increment of the cardiorespiratory and musculo-skeletal capacities. In relation to it, some NATO nations do not have jet management programmes for aircrew obesity (table 7) and the number of pilots who exercise regularly is in some nations far away from the expected goal of 100% (table 8). Consequently, physical programmes and other directed to prevention and management of obesity should be considered

Cigarrette smoking significantly .ncreases the risk of atherosclerosis, potenciating the effects of other risk factors . In table 9 we can see the very high percentage of smokers among some of the NATO crews which has to be considered to be reduced.

Alcohol consumption is responsible for an in-flight aircrew deficit performance even geater than on the ground (Schroeder 1971), involving an increased risk of aircraft accident even after the alcohol has been cleared from blood (Yesavage 1986). Besides its effects on the nervous, vestibular and cardiovascular systems it can act on the liver producing hypoglicemia, some times several hours after ingestion, which further compromise the flight safety. Most of the NATO nations have regulated the alcohol consumption (table 10). The 12 hours prohibition is the most accepted rule, but it can be insufficient after a heavy alcohol abuse and can raise discussion about the topic.

Modification of the aircrew dietary and lifestyle habits is the most feasible way to improve health and to prevent the above mentioned metabolic disorders. Recommended nutrition principles for developed countries, submitted by a number of health organizations are very similar (table 11) and they are fully applicable to the aircrew.

The flight surgeon plays a fundamental role by educating his squadron personnel about right dietary and lifestyle habits, as actually happens nowadays in most of the NATO nations.He should be involved in the elaboration of the aircrew menus, task which ideally should require the intervention of a qualified dietician. For the time being, flight surgeons and dieticians very seldom elaborate the flying personnel menus in NATO nations, in which is somebody else responsability (table 12). This fact may somehow contribute to the unsatisfactory self-evaluation of the own catering facilities by an important number of NATO Air Forces (table 13).

The NATO nations, that are represented here, have remarkable differences between them in terms of diet and lifestyle. The diet of the different populations is the result of natural resources, climate, technical and industrial progress relating to living standards, religion and also tradition. Modern advertising also has a strong influence that unfortunately is not always beneficial. The per capita income of one nation does not necessarily correlate with the quality of the diet . Some of the NATO nations that are among the wealthiest in the world have a very high intake of saturated fat and hence a high incidence of CHD, when compared with other countries studied.

The diet and lifestyle of any given Air Force tends to be a reflection of the habits of its nation's civil population. In countries in which there is a high fat ingestion, high incidence of smoking and sedentary attitudes, the Air Force personnel are affected by the same habits and suffer the clinical consequences. It is obvious that dietary and lifestyle changes have to be introduced in the general population through education, motivation and adequate stimulus. Nontheless the AMP, regardless of the assumed NATO differences, may do something more than expecting an improvement of the dietary and lifestyle education of the civil population from which the aircrew will be selected. The way of doing this is by organising activities such short courses , lecture series or symposiums, such as this one, related to the topic. The publication of these activities will provide the flight surgeons of the different NATO nations with valuable tools to act over their Air Force staff and aircrew, intoducing changes in their dietary and lifestyle habits according to different type of aircrew and missions,contributing to the success of the air operations.

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Table 1

CARDIOVASCULAR RISK FACTORS

NONINFLUENCEABLE	INFLUENCEABLE
-Sex	-Hipercholesterolemia (LDL-c increase)
-Age	-Low levels of HDL-c and other lipid metabolism abnormalities
-Family History	-Hypertension
	-Cigarrette smoking
	-Diabetes
	-Obesity
	-Sedentary behavior
	-Fibrinogen & Factor VII increase
	-Psychosocial factors

Table 2.
PARAMETERS ROUTINELY CHECKED AT THE PHYSICAL EXAMINATION OF THE MILITARY PILOTS.

	T-CHOL	HDL-CHOL	LDL-CHOL	VLDL-CHOL	APO	TRIGL	URIC	BG
BELGIUM	Y	Y	Y			Y	Y	Y
CANADA	Y	Y						Y
DENMARK	Y	Y	Y			Y		
FRANCE	Y	Y				Y	Y	Y
GERMANY	Y	Y			Y	Y	Y	Y
GREECE	Y					Y	Y	Y
ITALY	Y	Y				Y		Y
NETHERLANDS	Y	Y				Y		Y
NORWAY	Y	Y				Y		Y
PORTUGAL	Y	Y	Y	Y		Y	Y	Y
SPAIN	Y	(1)	(1)			Y	Y	Y
TURKEY	Y	Y	Y			Y	Y	Y
U. K.	Y					Y	Y	Y
US ARMY	Y	*						
USAF	Y	(1)						(2)
US NAVY	Y	Y						(2)

```
*      STARTING IN 1.992
(1)    WHEN TOTAL CHOLESTEROL ELEVATED
(2)    WHEN FAMILY HISTORY OF DIABETES
```

Y - yes

Table 3.
PERIODICITY OF THE BIOCHEMICAL CONTROLS

	T-CHOL	HDL-C	LDL-C	VLDL-C	TRYGL	URIC	BG
BELGIUM	4Y(1)	4Y(1)	4Y(1)		4Y (1)	4Y(1)	2Y
CANADA	4Y(1)						4Y(1)
DENMARK	5Y						
FRANCE	1Y	1Y			1Y	1Y	1Y
GERMANY	1Y	1Y			1Y	1Y	1Y
GREECE	1Y				1Y	1Y	1Y
ITALY	1Y	1Y			1Y		1Y
NETHERLANDS	1-2Y	1-2Y			1-2Y		1-2Y
NORWAY	1Y(2)	1Y(2)			1Y(2)		1Y(2)
PORTUGAL	1Y	1Y	1Y	1Y	1Y	1Y	1Y
SPAIN	3Y(3)	(3)	(3)	(3)	1Y	1Y	1Y
TURKEY	1Y	1Y	1Y		1Y	1Y	1Y
U. K.	2Y(3)				2Y(3)	2Y(3)	2Y(3)
US ARMY	1Y	1Y(6)					
USAF	2Y(5)						
US NAVY	3Y	3Y					

```
(1) EVERY 2 YEARS AFTER 40
(2) EVERY 6 MONTHS AFTER 40
(3) EVERY 1 YEAR AFTER 40 OR WHEN ELEVATED.
```

Table 4.
LIMIT VALUES FOR REJECTION. (mg/dl).APPLICANTS FOR PILOT TRAINING.

	T-CHOL	HDL-CHOL	T/HDL-C	TRIGL	URIC	BG
BELGIUM	250	<40		200	7	105
CANADA	90 % P.V.		6			GTT
DENMARK	300		6			
FRANCE	300			200		DM
GERMANY	200 (1)	<35		200	8	100
GREECE	240			140	7	115
ITALY	200 (2)	<40		175		110
NETHERLANDS	Normal values.					
NORWAY	Evaluated in combination with other risk factors					
PORTUGAL	Normal values			-		110
SPAIN	250	<35	6	200	7	115
TURKEY	300	<35	6	200	6	110
U. K.	Evaluated in combination with other parameters					
US ARMY	-	-	-	-	-	115
USAF ·	300	-	6	-	-	115
US NAVY	-	-	-	-	-	110

(1) 300 mg/dl for continuation

(2) 240 mg/dl "   "

Table 5.
POLICY WITH MILITARY PILOTS SHOWING ALTERATION OF THE
BIOCHEMICAL PARAMETERS AT THE PERIODICAL MEDICAL EXAMINATION

	CARBOHYDRATE	LIPIDS
BELGIUM	repeat test	control 1 month
CANADA	GTT. Hb A1 C	treatment
DENMARK	treatment	treatment
FRANCE	diet.exer. advise	diet exer advise
GERMANY	further evaluat.	further evaluat.
GREECE	repeat test	repeat test
ITALY	Fructosemine. Hb A1 C	repeat test
NETHERLANDS	further evaluat.	further evaluat.
NORWAY	Information	Information
PORTUGAL	further evaluat	further evaluat
SPAIN	GTT. Hb A1C	diet, ex, drugs
TURKEY	Repeat every 2 weeks	Repeat every 2 weeks
U. K.	further evaluat	further evaluat
US ARMY	GTT. HbA1C	diet, ex, drugs.
USAF	further evaluat.	diet, ex, drugs (non HPF)
US NAVY	further evaluat.	diet, ex, drugs (non HPF)

Table 6.
WHEN DIABETES MELLITUS IS DETECTED IN ONE EXPERIENCED PILOT

	grounded	exer+diet	is permited to fly on		
			sulphonil.	biguan.	insulin
BELGIUM	Y. Temp.	Y	Y(1)	Y(1)	N
CANADA		Y			
DENMARK		Y	N	N	N
FRANCE		Y	N	Y	N
GERMANY	Y	N	N	N	N
GREECE		Y			
ITALY		Y	Y	N	N
NETHERLANDS	Y Initial.	Y	N	N	N
NORWAY		Y	N	N	N
PORTUGAL		Y			
SPAIN		Y	N	N	N
TURKEY	Y	Y	N	N	N
U. K.	Y temp.	Y	Each case judged individually		
US ARMY		Y	N	N	N
USAF		Y	N	N	N
US NAVY		Y	N	N	N

(1) With weaver and after stabilization of the diabetes

Y = yes , N = no

Table 7.
NATIONS WITH ESTABLISHED MANAGEMENT PROGRAM FOR OBESITY

	YES	NO
BELGIUM	+	
CANADA	+	
DENMARK	+	
FRANCE		+
GERMANY	+	
GREECE	+	
ITALY		+
NETHERLANDS		+
NORWAY	+	
PORTUGAL		+
SPAIN		+
TURKEY		+
U. K.	+	
US ARMY	+	
USAF	+	
US NAVY	+	

Table 8
ESTIMATION OF THE PERCENTAGE OF NATO FLYING POPULATIONS THAT
DO EXERCISE REGULARLY.

BELGIUM	30 %
CANADA	75 %
DENMARK	50 %
FRANCE	95 %
GERMANY	65 %
GREECE	20 %
ITALY	40 %
NETHERLANDS	50 - 75 %
NORWAY	80 %
PORTUGAL	40 %
SPAIN	20 %
TURKEY	30 %
U. K.	NO DATA
US ARMY	100 %
USAF	80 %
US NAVY	100 %

Table 9.
ESTIMATION OF PERCENTAGE OF SMOKERS OF NATO FLYING POPULATIONS

BELGIUM	35 %
CANADA	25 %
DENMARK	50 %
FRANCE	28 %
GERMANY	30 %
GREECE	54 %
ITALY	40 %
NETHERLANDS	50 %
NORWAY	30 %
PORTUGAL	50 %
SPAIN	47 %
TURKEY	48 %
U. K.	NO DATA
US ARMY	20% in >40 y. 5% in <40 y.
USAF	10%
US NAVY	20-25% in >40 y. 5-10% in <40 y.

Table 10.
REGULATION OF ALCOHOL CONSUMPTION

	NO REGULATED	YES	HOURS PREFLIGHT
BELGIUM		+	12
CANADA		+	8
DENMARK		+	(1)
FRANCE		+	
GERMANY		+	12
GREECE		+	12
ITALY	(2)	•	
NETHERLANDS		+	10 (3)
NORWAY		+	10
PORTUGAL	+		
SPAIN	+		
TURKEY		+	12
U. K.		+	(1)
US ARMY		+	12 (4)
USAF		+	12
US NAVY		+	12 (5)

(1) depends on the amount of alcohol consumption.

(2) alcoholic beverages are not recommended 8 h. before fligth

(3) 24 h. after large intake

(4) 24 h. recommended

(5) between the last intake and the beginning of crew brief

Table 11

Dietary guidelines

1. Total calories supplied should be adequate to achieve and maintain the body weight close to the "ideal" value.

2. Decrease protein intake to approximately 15% of the total calories.

3. Carbohydrate intake should not be less than 50% of the total calories, with emphasis on complex carbohydrate and fiber, also limiting the amount of sugar.

4. Decrease the lipid intake to less than 30% of the total calories, the saturated fat to less than 10% and cholesterol to less than 300 mgs per day.

5. Decrease the sodium intake to less than 3 g. per day.

Table 12.
THE RESPONSABILITY OF ELABORATING THE MENUS AT THE AIR BASES.

	DIETITIAN	FLIGHT SURGEON	OTHER
BELGIUM	N	N	Y
CANADA	Y	N	N
DENMARK	N	N	Y
FRANCE	N	N	Y
GERMANY	N	Y	N
GREECE	N	Y	N
ITALY	N	Y	N
NEDERLANDS	N	N	Y
NORWAY	N	N	Y
PORTUGAL	Y	N	Y
SPAIN	N	N	Y
TURKEY	N	N	Y
U. K.	N	N	Y
US ARMY	Y	N	N
USAF	*	*	Y
US NAVY	*	*	Y

* OCCASIONALLY AT SOME AF BASES.

Y = yes , N = no

Table 13.
SELF-EVALUATION OF THE CATERING FACILITIES

	VERY UNSATISF.	UNSATISF.	NORMAL	SATISF.	VERY SATISFAC.
BELGIUM				*	
CANADA					*
DENMARK		*			
FRANCE					*
GERMANY				*	
GREECE				*	
ITALY			*		
NETHERLANDS			*		
NORWAY			*		
PORTUGAL		*			
SPAIN		*			
TURKEY			*		
U. K.		*	*		
US ARMY			*		
USAF		*			
US NAVY		*	*	*	

AN AUTOMATED PROCESSING SYSTEM FOR FOOD FREQUENCY AND NUTRITION KNOWLEDGE QUESTIONNAIRE

Dr A.M.J. Van Erp-Baart, Ing. C. Kistemaker, Dr M.R.H. Löwik
TNO Nutrition and Food Research
Department of Human Nutrition
P O Box 360
3700 AJ ZEIST, The Netherlands

INTRODUCTION

In surveys and intervention studies food frequency questionnaires are often used to assess habitual dietary intake. Although this is a relatively quick and simple method, the number of subjects to be examined can still be enormous. So, without a good system, the time needed for the processing of the amount of data may be prohibitive for starting such a project. To structure and speed up this work, we developed FOFRIPS: a food frequency interactive processing system. Starting point was that not each developed specific questionnaire should be automated, but instead only the general procedures of the data processing.

FOFRIPS system

In figure 1 the construction of the FOFRIPS system is presented. The right part is the general framework. It contains all general programs for data processing. It comprises software for interactive data entry, general control and calculation programs and an interactive mutation program.

The left part contains all questionnaire specific information and procedures.
First of all the questionnaire has to be defined in simple text files, so that FOFRIPS "knows" what should be processed.
Furthermore, for each questionnaire extra control, calculation and correction procedures can easily be incorporated in the general software. These procedures can be tailored to the kind of questionnaire and the required precision in the calculated dietary intake.

The general framework is the job for the computer experts, based on guidelines of the nutritionist.
The questionnaire specific information can easily be filled in by nutritionists and dietitians without much knowledge of programming. So, it is the nutritionist who determines the content of the procedures and is also responsible for it. This is a necessity, because these procedures can affect the results and interpretation of the questionnaire.

CONTROL AND CORRECTION PROCEDURES

As mentioned before some basic checks are part of the software of the general framework.
First of all it is checked whether the answers are complete and which items are missing. Then, some checks are performed that compare the given answer with the defined characteristics per question. For instance, if the consumed amount is higher than the stated maximum or lower than the stated minimum, it is reported. Also it is checked whether information is available on the consumed amount when the consumption frequency is higher than zero.
Besides these fundamental checks it is also possible to perform extra checks tailored to the questionnaire. For instance, checks on consistency of consumption frequencies (like vegetables) of several items can be performed.

When the control programs indicate particular mistakes in the entered questionnaires, they can be corrected using an interactive mutation program which is part of the general framework. The originally given answer can be

changed interactively in the dataset. For general mistakes, it is also possible to work with automated correction procedures. This kind of error has to be defined afterwards in the specific questionnaire.

CALCULATION PROCEDURES

When all checks and corrections are performed, the dietary intake figures based on the questionnaires can be calculated. Calculated is the mean daily consumption of all food products of the questionnaire in grammes for all individuals. In the calculation procedure the following aspects are taken into account in the general framework:
- seasonal factor
- the frequency factor
- the number of units consumed (for instance 2 buns) and
- the portion size in grammes of one unit (for instance 50 g/bun).

The individual daily consumption of food products in grams can easily be converted to nutrient intake by using a computerized food composition table. (for the Netherlands the NEVO Food Composition Table) Besides these general calculations, some supplementary calculation procedures can be incorporated for the specific questionnaire. For instance a correction factor can be added to correct over- or underestimation of consumption frequencies of food items. Moreover it is possible to perform more complicated calculations of additional food items, which are not explicitly asked for in the questionnaire, but which can be deduced from other items of the questionnaire.

FLEXIBILITY

As indicated in the title of this paper other types of questionnaires can also be processed with this system. Nutrition knowledge, general information and physical activity questionnaires can be defined in FOFRIPS as well.

CONCLUSION

Fofrips can be applied to a wide range of questionnaires. Food frequency, nutrition knowledge, but also other lifestyle questionnaires can be processed.
Therefore it is a very flexible system. The work of the computer experts is minimized. The nutritional expert is responsible for specific procedures
A standardized protocol is used, which means quality control for the different questionaires of one time but also over time.

TECHNICAL INFORMATION

The FOFRIPS programs can be run on a VAX system as well as on standard PC configuration.

FUTURE PERSPECTIVE

The FOFRIPS system is currently implemented in a knowledge based system, which can be used to analyse individual consumption patterns, to identify consumption related health risks and to give dietary advice to change the pattern step by step.

FOFRIPS = Food Frequency Interactive Processing System

definition of the questionnaire →

specific control procedures →

specific calculation and correction procedures →

FOFRIPS General framework
interactive data entry program
general control program
interactive mutation program
general calculation program

specific → **nutritionist**

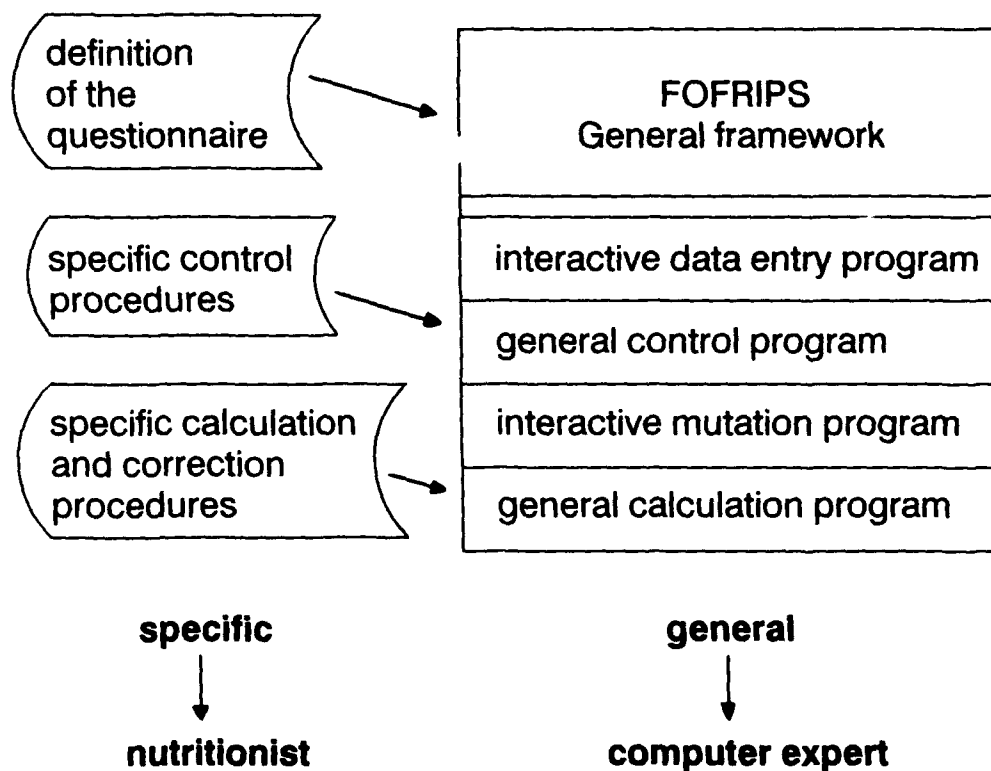**general** → **computer expert**

Figure 1.

NUTRITIONAL ASSESSMENT OF UNITED STATES TACTICAL AIR COMMAND PILOTS

S.D. Hart Yevich
S.J. Yevich
C. Morrison
College of Public Health
University of South Florida, Tampa, FL 33612
USA

SUMMARY

The nutritional status of 184 TAC fighter pilots was analyzed for caloric intake, macronutrient composition, alcohol intake, and meal frequency. The dietary habits of fighter pilots relative to their age, family configuration, and level of exercise were also examined. The diets of a sub-group of 43 F-16 student fighter pilots were correlated with the subjective graded performance of a Basic Fighter Manuever. Pilots' energy consumption of 2800 kcal fell within the suggested range for the average U.S. male. The macronutrient composition of their diets was better than that of the mean U.S. male, comprising an average of 46% carbohydrates, 34% fats, 15% protein, and 5% alcohol. Missed meals on the day of flying were a frequent occurrence. The older age pilots consumed less fat than their younger counterparts, but their intake of alcohol was greater. Family configuration had no effect on alcohol consumption, caloric intake, or dietary behavior. Pilots who exercised 4 to 7 days a week were heavier than the non-exercisers, and the non-exercisers consumed more alcohol. No statistical difference could be found between total performance scores in the sub-group of F-16 student pilots and any deficiency or excess of specific dietary components or any combinations of these components. Alcohol consumption was shown to be associated with a low G-tolerance score.

1   INTRODUCTION

The influence of diet and overall nutritional status on an individual's ability to perform in the increased acceleration environment is an important aeromedical concern, although relatively little data are available for the special case of the high performance pilot.(1) The demands on a fighter pilot to maintain aircraft control are of an immediate and unforgiving nature. The point at which the physical, mental, and emotional responses, and thus the pilot's performance, are degraded by poor nutritional status, is unknown.

The performance demands of piloting sophisticated jets have been compared to those imposed on elite athletes. DeHart has compared the physical demands on fighter pilots to that of weight lifters, sprinters, or swimmers.(2) Requirements for hand-eye coordination, pinpoint accuracy, quick reaction time, detailed exactness, and smoothness of actions are similar to the skill demands for basketball players, pentathletes, and golfers. However, factoring in just a few additional stressors such as the hectic schedules resulting in interrupted sleep cycles and missed meals, the changes in time zones, the rigorous and continual training, plus the competition of combat, it can be seen that the pilot population functions under extraordinary pressure. As the diet of the athlete clearly affects his or her performance (3), so must the fighter pilot's overall performance be affected by his or her nutritional status.

Research on the comparable population of athletes has shown that exercise performance can be improved when athletes consume carbohydrates before exercise.(4) Work performance, as measured by fatigue, concentration, and reaction time, is substantially decreased in subjects whose diets were deficient in complex carbohydrates.(5) Also, the ingestion of concentrated amounts of simple sugars (as found in many quick-snack food items) may lead to functional hypoglycemic episodes which can dramatically impair physical and mental performance.(6) Controversy, however, exists surrounding the actual role of these

simple sugars in inducing a hypoglycemic effect (the "highs" or "lows"). It is possible that this is confined only to a limited sensitized population, while the vast majority of physically active people are able to metabolize sugars without experiencing a blood glucose imbalance.(7)

Dietary requirements are recognized by the United States Air Force (USAF) as being extremely important, and numerous sources of nutrition information and advice are provided to pilots.(8) The effects of improper or irregular eating habits over an extended period of time are noted to contribute to fatigue, lack of a favorable attitude, human error, and possible aircraft accidents, while proper nutrition is noted to increase one's energy level, endurance capability and overall performance.(8, 9) Aeromedical literature has shown that there is an increased G-duration tolerance in the fed versus fasted, and induced hyper-versus hypoglycemic states in pilots.(1) Combined sodium and fluid restrictions are known to decrease G tolerance. (10, 11)

Over the past 3 years, 61 incidents involving combat fighter pilots have been reported in which missed meals or poor eating habits were determined to be contributory in causation.(12) These were related to tunnel vision, illness, hypoxia, and loss of consciousness. Thus, nutrition and its potential effect on pilot performance must play an important role in increasing the competitive edge of pilots, preventing unnecessary loss of human life, and decreasing the financial loss due to aircraft accidents.

Because of the recognized importance of diet and performance and because there is little hard evidence to elucidate the real state of pilot nutrition, this study was designed to gather data describing TAC pilot's consumption of carbohydrates, protein, fats, and alcohol. In addition, the effects of age, family configuration and exercise level on food consumption were examined. In a smaller subgroup of F-16 student fighter pilots, the effects of short termed dietary intake on flying performance, as measured by the subjective grading of their instructors, were analyzed.

2   METHODS

One hundred eighty-four F-15 and F-16 TAC pilots were voluntarily enrolled in this study between July 1989 to April 1992. This sample was comprised of 141 active duty pilots at Langley, Shaw, Eglin, MacDill and Hill Air Force Base's (AFB) and 43 student fighter pilots undergoing initial F-16 training at MacDill AFB. For the purpose of this study, the pilots were grouped three ways: by family configuration, exercise patterns, and by age. The family configuration category divided pilots as single, couples without children, and couples with children. Exercise groupings were: no exercise, 1 to 3 days of exercise, and 4 or more days of exercise per week. The age categories included younger than 30 years of age, 30 to 39, and 40 and older.

Each pilot kept a 3-day dietary record. Pilots were asked to eat normally and be as accurate in their food consumption recordings as possible. During a follow-up interview, the food recordings were reviewed and checked for accuracy by an exercise physiologist using food models to assure food portion size accuracy. Data on age, height, weight, exercise, family configuration, missed-meals and types of snacks were also collected during this interview process.

The 43 student fighter pilots in the subgroup population were

evaluated for their performance in a specific maneuver during the "B-course". The "B-course" is an elite selection, six month transition course for experienced Air Force pilots. It includes academics, simulator flying and F-16 flying with and without the instructor. The Basic Fighter Maneuver (BFM-10) was chosen as the measure of performance because it is considered the most physically and mentally challenging flight of the course. A 24-hour dietary recall was recorded on all 43 pilots prior to flying the BFM-10. The instructor's evaluation of performance was specially designed for this study by experienced B-course instructor pilots and was based on the actual mission effectiveness grading sheet. The areas of performance evaluated by the instructor were:

     A. Ability to pull Positive Gravities (+Gz) relative to other students at the same stage of training;

     B. Situational awareness relative to other students at this same stage of training;

     C. The role that channelized attention and overall task saturation played in the student's performance on the day of the flight;

     D. "Switchology" (adeptness and knowledge of cockpit instrumentation) relative to other students at this same stage;

     E. Performance on this BFM relative to other students at this same stage of training;

     F. Overall comparison of the student with his peers.

Each specific area was graded on a sliding scale from 1 to 5 of "worse than others" (lowest rating = 1) to "better than others"(highest rating = 5) within an hour of the BFM-10. Anonymity of the grading was maintained, and the instructor's grade sheets were never seen by the students. The grader's credentials as an F-16 pilot were also ascertained in the questionnaire.

Analysis. The PruCal Dietary Analysis Program developed by the Department of Food Science and Human Nutrition at Colorado State University (CSU) was used to analyze the three day diet of the pilots.(13) The foods in the computer code list were selected for the CSU nutrient file based on the United States Department of Agriculture (USDA) Nutrient Data Base. Statistical analysis of data were by SAS software. A one-way ANOVA at the 0.05 significance level was used on each category to determine differences in pilot groups with respect to: weight, total calories, percentage of calories derived from protein, fat, carbohydrates, and alcohol. Differences between the pilots' normal (3-day) diet and the preflight (24-hour) diet were examined by T-test for paired comparisons. Associations between specific dietary components and performance rating were examined by correlation analysis (Pearson, Spearman, and Kendall) as well as by linear regression and non-parametric tests (Wilcoxon, Kruskal-Wallis).

3   RESULTS

The pilots ranged in age from 23 to 43 years old, with a mean age of 30. Their average height was 177.8 cm and weight was 79 kg. Average food intake was 2800 kcal, comprised of: 15% protein, 46% carbohydrates (26% complex carbohydrates and 20% simple sugars), 34% fat and 5% alcohol.

No differences were found among family configuration groupings for any of the variables studied. (Table 1) The pilots' domestic arrangements did not appear to have a significant effect on pilot weight or diet.

Data describing the exercise levels of the pilots are presented in Table 2. Exercise groups differed significantly with respect to weight (F 2, 181 = 5.49, P < 0.05) and percentage of carbohydrates (F 2, 181 = 3.73, P < 0.05) contributing to total calories. Scheffe post-hoc tests revealed the group which exercised four or more days per week was significantly heavier than the group which did not exercise. No other weight differences were found among the exercise groups. The group which exercised one to three times per week derived a significantly greater percentage of their total calories from carbohydrates than the group which did not

exercise. In addition, the group which did not exercise had a significantly higher percentage of caloric intake due to alcohol than the other groupings (F 2, 181 = 6.31, P< 0.05). Exercise groupings did not differ with respect to total calories consumed or the percentage of calories contributed by protein or fat.

Table 3 contains pilots' nutritional information based on age. Age groups differed with respect to percentage of calories contributed by fat (F 2, 181 = 4.85, P < 0.05) and percentage of calories derived from alcohol (F 2, 181 = 12.70, P < 0.05). Scheffe post-hoc tests revealed the oldest age group had a significantly smaller percentage of total calories contributed by fat, but a significantly greater percentage of total calories from alcohol than the other younger groups. Age groups did not differ with respect to weight, total calories, or the percentage of calories contributed by protein or carbohydrates.

Sixty-five of the 184 pilots (35%) missed breakfast within the 3-day diet recording, and 40 of those 65 pilots (62%) reported flying the same day that this meal was missed. Fifty-six (30%) of the pilots reported missing lunch, and 43 (77%) of these also flew afterwards. Fourteen pilots (8%) reported missing both breakfast and lunch, and 86% of these also flew the same day.

No significant difference in the total performance score of the 43 F-16 student fighter pilots could be associated with a deficiency or excess of any specific dietary component (including simple sugars or complex carbohydrates) or any combination of these components. No associations between poor performance and missed-meals could be demonstrated. Twenty-one percent of the pilots admitted to alcohol usage within 24 hours of the BFM-10 evaluation. Two students who consumed the most alcohol within 24 hours of the BFM showed poor performance relative to others in Gz, switchology, and defensive BFM. Interestingly, however, their channelized attention was very good. By regression analysis, alcohol consumption was only associated with lower Gz score (P = 0.03). No other statistically significant difference could be established between drinkers and non-drinkers.

4   DISCUSSION

As a group, the pilots' heights and weights approximate those of the median U.S. male in the 25-50 year old age group.(14) Pilots' energy consumption of 2800 kcal was within the 2300 kcal to 2900 kcal range suggested for the median U.S. male.(14) Pilots in this study consumed on the average 105 g of protein, 322 g of carbohydrates, and 106 g of fat per day.

The median (79 kg) U.S. male has a suggested protein intake of 63 g.(14) All pilot groupings were similar in caloric intake derived from protein, and the average 105 g of protein consumed by the pilots exceeds the recommended daily allowances (RDA = 0.8 g/kg).

The average carbohydrate intake of 322 g consumed by the pilots represented a mean contribution of 46% of their total caloric intake. This is comparable to the findings of Copp et al. (48%) in a survey of 30 fighter pilots at Tyndall AFB.(15) While this is approximately the same as for the average adult U.S. male, it is less than the 55-plus percent suggested by the National Research Council.(14)

The caloric intake from fats for the average pilot in this study was 34%. This finding was the same as the Copp et al. study, and while it is better (less) than the average American fat consumption (42%), it still exceeds the U.S. Guidelines by 4%.(15, 14) With respect to amount of fat consumed, the older pilots were significantly better than their younger counterparts.(Table 3) This older group met the dietary guidelines for fat of less than 30%. This may reflect a greater awareness of coronary risk factors by the older age groups.

The older age grouping of pilots consumed a greater amount of alcohol than those younger. A large number of pilots did not consume any alcohol at all (32%), and 34% derived less than 3%

of their kcal from alcohol. Alcohol slows reaction time, impairs coordination, provides empty calories and increases water elimination.(16) Low levels of energy and dehydration caused by too much alcohol can aggravate the stresses of flying. Block et al. found that alcoholic beverages are the third leading contributor of calories (11%) in the American diet.(17) We found that 21% of the pilots derived 11% or more of their kcal from alcohol. The lesser consumption of alcohol by the younger pilots may reflect the positive impact of education and the awareness of the greater demands of today's high performance aircraft.

The association between alcohol consumption and the ability to pull Gz's correlates well with previously reported findings.(18) In addition, two students admitting highest 24-hour alcohol consumption also had very low overall performance scores, but the association between overall performance and alcohol could not be shown to be statistically significant. A pilot who has consumed alcohol may be more acutely aware of his condition and may compensate for alcohol-induced metabolic disturbance by increasing his concentration. This topic bears further study, as the consumption of alcohol by the off-duty pilot is anecdotally high.

Those pilots who exercised 4 to 7 days per week were heavier than non-exercising pilots, possibly reflecting increased muscle mass. The group which did not exercise at all consumed more calories from alcohol than the two groups which exercised, probably reflective of a more sedentary lifestyle as opposed to the more health-conscious exercisers. The group which exercised 1 to 3 days a week showed a statistically significant increase in carbohydrate consumption over the non-exercisers. The reasons for this are not known.

An interesting observation was that the family configuration, whether single or a couple with or without children, had no effect on alcohol consumption, caloric intake, or pattern of consumption of nutrients. The pilot population probably represents an above-average, educated and health-conscious group such that their nutritional behavior is independent of their marital and family status.

Snacking behavior of pilots and the number of missed meals also indicate opportunities for dietary deficiencies. The majority of snacks were sodas, candy, donuts, and chips which contribute only simple sugars and fat and have little nutritional value. However, in the subgroup of F-16 student fighter pilots, no performance degradation could be detected when meals were missed or snacks substituted for meals.

Very few extremes were found in dietary behavior among the F-16 students, and there was not much variation in total calories, simple and complex carbohydrates, fats, protein, and alcohol. Although no decrement in overall performance could be demonstrated for nutrients, it is possible that the subjects metabolically compensated for their state of nutrition. This raises the question at what extreme in nutritional deficiency will the fighter pilots' performance begin to degrade? At what point will he not be able to compensate for dietary inadequacy? Are there specific combinations of nutrients which can increase or decrease pilot performance?

It was initially hypothesized that there could be a correlation between high consumption of simple sugars prior to performance and a decrease in concentration, channelized attention, and fatigue level. Although pilots' simple carbohydrate intake has repeatedly been shown to be above the suggested U.S. Guidelines, this increased intake could not be shown to degrade flying performance in the F-16 subgroup.

5   CONCLUSIONS

The average diet of the fighter pilot was found to be better than that of comparably aged average American males, and closer to that proposed by the U.S. Dietary Guidelines. While protein intake was high, fat consumption still was excessive, and

carbohydrates lower, than recommended standards. The findings were similar to the smaller study population of Copp et al.. Family configuration had no effect on the intake of any of the macro-nutrients, alcohol, or total calories. The grouping which exercised the most (4 to 7 days per week) were heavier than non-exercising pilots, and the non-exercisers consumed more calories from alcohol than the two other exercise groups. The weight differential most likely was due to increased muscle mass in the exercisers. The youngest group consumed more fatty foods than the oldest group, possibly reflecting greater concern for coronary artery disease in the older pilots. Both younger age groups drank less alcohol than the 40 and older group, possibly reflecting a raised level of consciousness in the new generation of fighter pilots.

In the F-16 sub-population, the lack of correlates of specific dietary nutrients (except for alcohol) with performance could be due to the less than optimal population available for enrollment. A larger population may have offered greater variation in diet and performance scores, and thus have increased the sensitivity of detection of differences in these. However, it is possible that the pilots' nutritional status was not compromised to a great enough extent to have a decremental effect on their performance. A well nourished pilot may be capable of easily compen.   for acute dietary inadequacies. The extent that they can com̦ ..sate for a more prolonged and/or pronounced imbalance in diet is unknown. This study showed an association between alcohol intake within 24 hours of flight, and poor Gz tolerance in a field setting, as measured by subjective, unbiased and experienced fighter pilot instructors. This could be of extreme importance in an operational setting.

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Table 1. Dietary and Descriptive Means and Standard Deviations for Pilots by Family Configuration.

	Single, N = 51	Couples without Children, N = 55	Couples with Children, N = 78
	X (SD)	X (SD)	X (SD)
Age (yrs)	28.33 (5.35)	28.69 (4.41)	31.83 (4.75)
Height (cm)	179 (5.44)	179 (5.54)	179 (6.78)
Weight (kg)	78.63 (6.82)	79.04 (8.11)	79.06 (7.79)
Calories/day	2880 (856)	2858 (772)	2710 (823)
Protein (%)	14.94 (3.39)	15.04 (2.82)	15.87 (2.59)
Carbohydrate (%)	45.41 (7.63)	44.66 (9.75)	45.74 (7.66)
Fat (%)	35.63 (6.59)	34.76 (6.35)	33.24 (5.74)
Alcohol (%)	5.28 (8.03)	5.75 (6.95)	5.31 (5.86)

Table 2. Dietary and Descriptive Means and Standard Deviations for Pilots by Exercise Group (per week). (**Bold** numbers indicate significance, P = 0.05)

	No Exercise, N = 51	1 to 3 days, N = 55	4 to 7 days, N = 78
	X (SD)	X (SD)	X (SD)
Age (yrs)	31.47 (6.03)	29.29 (4.41)	29.63 (4.61)
Height (cm)	176.5 (5.51)	177 (5.54)	180 (6.01)
Weight (kg)	76.31 (7.41)	77.14 (8.11)	**80.39** (7.41)
Calories/day	2569 (739)	2998 (772)	2803 (815)
Protein (%)	14.81 (2.91)	15.43 (2.82)	15.52 (2.96)
Carbohydrate (%)	**43.03** (8.59)	**48.19** (9.75)	45.12 (7.81)
Fat (%)	33.69 (5.78)	33.62 (6.35)	34.36 (6.19)
Alcohol (%)	**8.58** (9.34)	**3.19** (6.95)	**5.15** (5.70)

Table 3. Dietary and Descriptive Means and Standard Deviations for Pilots by Age Group. (**Bold** numbers indicate significance at 0.05)

	Under 29, N = 106	30 to 39, N = 64	40 and Older, N = 14
	X (SD)	X (SD)	X (SD)
Age (yrs)	26.45 (1.82)	33.17 (3.02)	41.63 (1.08)
Height (cm)	178.69 (5.73)	179 (6.24)	180 (7.56)
Weight (kg)	78.83 (7.57)	79.36 (7.11)	81.21 (9.71)
Calories/day	2886 (734)	2684 (894)	2702 (1014)
Protein (%)	15.45 (2.80)	15.45 (2.98)	14.29 (3.47)
Carbohydrate (%)	45.69 (7.47)	45.32 (9.28)	42.64 (9.64)
Fat (%)	**34.85** (5.99)	33.77 (6.28)	29.71 (5.46)
Alcohol (%)	4.29 (5.77)	5.55 (5.67)	**13.50** (12.11)

PORTABLE EQUIPMENT DEVELOPED TO ESTIMATE ENERGY EXPENDITURE BY SIMULTANEOUS RECORDING OF HEART RATE AND BODY POSITION.

A. Løvø[1]
B.E. Hustvedt[1]
A. Christophersen[1]
C.C. Christensen[2]
H.T. Andersen[2]

[1]) Institute for Nutrition Research
University of Oslo
PO Box 1046. Blindern. N-0316 Oslo, Norway

[2]) RNoAF. Institute of Aviation Medicine

1) SUMMARY

The operating principle of Actireg. a new device for registration of changes in human body positions. is described. It is robust and functions well also during prolonged periods of high physical activity. in contrast to accelerometers and other devices used as motion sensors.

Preliminary experiments indicate that combined use of heart rate and body position recording for estimation of energy expenditure may be superior to the use of heart rate registrations alone. However. validation experiments with doubly labelled water or a whole body calorimeter are needed in order to reach a firm conclusion on this point.

2) LIST OF SYMBOLS

ADC	Analog Digital Converter
BMR	Basal Metabolic Rate
E-Exp	Energy expenditure
ECG	Electro CardioGram
Flex-HR	Heart Rate limit
HR	Heart Rate
OOP	Object Oriented Program

3) INTRODUCTION

The introduction of portable equipment for long-term ECG registrations, and the well-known relationship between HR and physical activity level. has led to extensive use of HR recordings in order to estimate energy expenditure.

Many studies have been performed. but the results have been disappointing. the main reason being that HR and energy expenditure correlate well only at rather high activity levels (Ref. 1). At moderate or low activity. which is common during most of the day. there may be considerable variation in HR without concomitant change in energy expenditure. The reason for this is that HR is influenced also by factors other than physical activity, such as mental stress and shifts in body position with orthostatic effects upon HR.

As a consequence of the above-mentioned experience. an alternative approach for estimating energy expenditure from HR registrations has recently been presented (Ref. 2). The procedure described was: The experimentally determined HR/ energy expenditure relationship for each test person was inspected and a HR limit, named Flex-HR. was introduced. At HRs above Flex-HR. a linear HR/energy expenditure

recorded time with an energy expenditure factor. This factor was experimentally determined as the mean of the energy expenditure during quiet lying. sitting and standing activity. This fixation of an energy expenditure factor was rather arbitrary. because it was not based upon accurate information about the type and duration of activity taking place when the HR was below Flex-Hr. The authors claimed. however. that this procedure was an improvement compared to the previous method for estimation of energy expenditure from HR registrations.

There are considerable differences in the energy costs of lying. sitting and standing activities. Energy expenditure seldom exceeds 1.5 x BMR during normal sitting activities, whereas the energy cost of on-foot activities may be much higher. It has indeed been pointed out that daily energy expenditure is highly related to the time spent in standing activities (Ref. 3).

We therefore reasoned that the estimation of energy expenditure might be improved by simultaneous recording of HR and body position. We have constructed an instrument. named *Actireg*. capable of continuous registration of body position minute by minute for several days. and in this paper we report the results from the first experiment.

4) MATERIALS AND METHODS.

4.1) Test subjects.

The test subjects were female nutrition students. Their age. body weight and height will appear from Table 1. They volunteered to participate after the purpose and possible risks of the experiment had been explained to them.

4.2) Experimental protocol.

The experimental period lasted for 5 days. starting Monday morning. During this period. the students registered their food intake and recorded HR and body position. and they weighed themselves daily. After this 5 day experimental period, the following measurements were performed twice. on separate days: BMR. oxygen uptake and HR during sitting and standing. and during walking on a treadmill.

Person nr	Age (years)	Height (m)	Weight (kg)
1	23	1.66	55
2	25	1.73	64
3	26	1.64	53
4	23	1.71	66

Table 1. Age, body height and weight of the 4 test subjects.

4.3) Registration of body position.

4.3.1) Operating principle of the Actireg.

The Actireg is a device for registration of changes in human body position. It consists of two tilt switches connected to a battery operated storage unit with a real time clock. The unit measures 5 x 6.5 x 2 cm, weighs 125 g, and is carried fastened on a waist belt. It can be connected to the RS232 port of a microcomputer for parameter setting, starting, and data transfer. During operation, one tilt switch is mounted on the breast and the other on the leg above the knee, both of them with their longitudinal axes parallel to the longitudinal axis of the body. The status of the tilt switches is checked with intervals of 2 seconds, and information about any change in status is stored in the memory. When both are horizontal the value is 3, when both are vertical the value is 0, and correspondingly 1 or 2 is displayed when one is vertical while the other is horizontal. The body positions corresponding to these values are shown in figure 1. Information about periods when the Actireg is switched off during an experiment, as for instance when the test subject is taking a bath, or during the change of batteries, is stored as the value 7.

4.3.2) Use of the Actireg.

The test subjects made body position registrations for 5 consecutive days, from Monday morning and until Friday evening

4.4) HR registration.

HR was monitored in the laboratory and in daily life situations with a cardiofrequency meter (Sport Tester PE 3000, Polar Electro, Kempele, Finland). The system consists of an electrode-belt transmitter and wrist microcomputer receiver that stores the HR in the memory. The HR was recorded at 1-min intervals up to a maximum recording time of 33 h, when stored information was retrieved and the memory reset. The information was transferred to a microcomputer via an interface unit.

4.5) Body weight.

Body weight was recorded daily to the nearest 0.1 kg, using an electronic scale (Soehnle Digital, Soehnle-Waagen GMBH & Co, Mürrhardt/Württ, FRG).
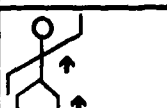
BODY POSITION	↑ =OFF → =ON	TILT SWITCH		SIGNAL STORED
		BREAST	LEG	
STANDING		OFF	OFF	0
LEANING FORWARD		ON	OFF	2
SITTING		OFF	ON	1
LYING		ON	ON	3

Figure 1. The operating principle of the Actireg.

4.6) Food intake registration.

The test subjects were supplied with electronic scales (Philips, HR2383, ±1 g) and weighed all food and fluid consumed during the 5 day experimental period. Total energy intakes were calculated using a food data base and software systems developed at The Section for Dietary Research, University of Oslo.

4.7) Measurement of BMR and oxygen uptake during sitting and standing.

The students stayed overnight at the institute. The BMR measurements took place in the morning (between 0700 and 0800) after an overnight (10-12h) fast. Before the actual measurement all subjects rested in bed for at least 30 min. Oxygen consumption and carbon dioxide production was then recorded for 30 min. The measurements were performed in an open calorimetric system. The bed with the ventilated hood was placed in a separate room with ventilation with outdoor air.

Air was drawn through the hood by a membrane pump and dried by granulated $CaCl_2$. The flow rate, 28-32 L min^{-1}, was measured on the dry gas by an electric turbine flowmeter (Omniflow model FTC-8N2.5-GJS), Flow Technology, Phoenix, AZ. The concentration of O_2 in the dried gas was continuously measured by an O_2 analyser (model S-3A, Applied Electronics, Sunnyvale, CA). The CO_2 was determined by an infrared gas analyzer (Binos-IR, mod 1, Leybold-Heraeus, FRG). The instruments were calibrated against dried outdoor air and a calibration gas mixture containing approximately 1% CO_2 and 20% O_2. Pure N_2 was used as zero gas. Care was taken to adjust the gas flow in the system so that the concentration difference for CO_2 and O_2 between air in and out of the respiratory chamber was kept in the range 0.5-1.0%. The analog outputs from the gas analyzers and flowmeter were sampled by a microcomputer using an ADC (Lab-Master, Scientific Solutions Inc, Ohio)

storage of the results. A mean value for O_2 consumption and CO_2 production was calculated from the average reading of the instruments each minute. The results were stored as sequential data files accessible for further calculations.

The oxygen uptake during sitting and standing was measured with the same instrument system by means of a hood placed over the shoulders of the subjects. giving freedom to move the head.

The energy expenditure was calculated from the O_2 consumption using an energetic equivalent for O_2 of 20 KJ / l.

4.8) Measurement of oxygen uptake and HR during exercise.

These measurements were performed by using a treadmill and the EOS-Sprint Exercise Test System (E. Jaeger GMBH. Wuerzburg. FRG). The exercise program consisted of 5 periods of each 6 min. duration and with increasing intensity up to an energy expenditure of about 8 x BMR for each person. and it was repeated at least once. The recordings from the last 2 min. of each period were used for determination of oxygen uptake and heart

4.9) Calculations

Calculations was performed by a Windows 3.1 OOP program developed in Turbo Pascal for Windows v. 1.5. The computer reads in parallel the two datafiles and combines them in instances of an object that stores the time. position and HR plus some other values. in a two-way list. Presentations of the data can be produced in several ways, the sum of energy as the most basal.

Energy expenditure was calculated minute by minute as follows: If the recorded HR > Flex-HR, energy expenditure was calculated from the linear regression line E-exp = $a + b$ x HR. If the recorded HR <= Flex-HR, calculated energy expenditure is equal to the energy expenditure factor for the concomitantly recorded body position.

5) RESULTS

5.1) Energy intake and body weight.

The average energy intakes for the 5 day study period are presented in table 2. There was a considerable variation, from 6.98 MJ/day for person no. 3 to 11.64 MJ/day for person no 4. The subjects recorded their body weights daily (data not presented). The weights were very stable during the experimental period.

5.2) BMR, and sitting and standing energy expenditure.

The data for BMR, and for sitting and standing energy expenditure, are also shown in table 2. The sitting and standing energy expenditures have also been calculated as multiples of BMR (BMR factors), and presented in table 3.

These low values show that the subjects, in accordance with the instructions, were sitting and standing quietly during the measurements.

5.3) The relationship between energy expenditure and heart rate.

The data on energy expenditure and heart rate are shown in figure 2. Linear regression analysis was performed on the data sets. The equations were:

Person no 1: E-exp = -12.9 + 0.327 x HR

Person no 2: E-exp = -21.3 + 0.444 x HR

Person no 3: E-exp = -16.8 + 0.388 x HR

Person no 4: E-exp = -22.3 + 0.406 x HR

5.4) Estimation of energy expenditure.

The estimated energy expenditures are presented in table 4. The calculations were performed as described in paragraph 4.9. The energy expenditure factors used for sitting and standing positions were those presented in table 3. The factor

Person no.	E intake MJ/day	BMR kJ/min	Sitting E-exp kJ/min	Standing E-exp kJ/min
1	7.54	3.66	4.21	4.32
2	10.37	4.54	4.99	4.99
3	6.98	3.66	4.65	4.43
4	11.64	4.68	6.04	6.27

Table 2. The E-intake, BMR, sitting and standing E-exp of the 4 subjects.

for the leaning forward position was set equal to standing. Calculations were performed repeatedly with the different values for Flex-HR shown in table 4. and expressed as per cent of the recorded energy intake for each person. Assuming energy balance. the "best" estimate is therefore that which is close to 100. It appears from the table that the "best" estimate was obtained at Flex-HR 2. which is the heart rate when energy expenditure is 3 x BMR. corresponding approximately to the energy cost of normal walking. This estimate was "better" than the estimate at Flex-HR 1. which is the heart rate when energy expenditure is 2 x BMR, corresponding approximately to the Flex-HR used in a

Person nr	Sitting E-exp/BMR	Standing E-exp/BMR
1	1.15	1.18
2	1.10	1.32
3	1.27	1.21
4	1.29	1.34

Table 3. Sitting and standing energy expenditure, expressed as multiple of BMR.
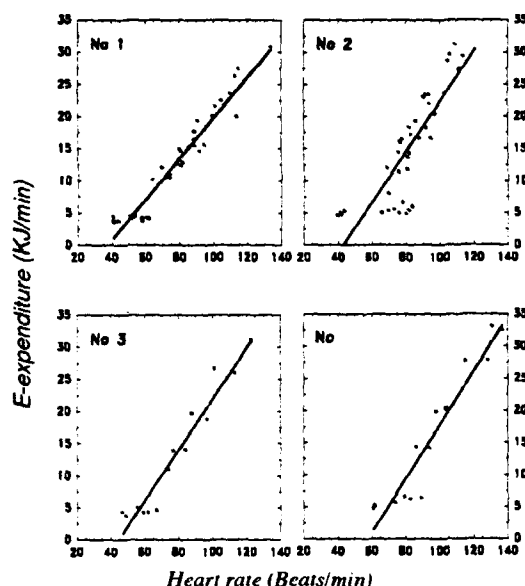
Figure 2. Energy expenditure / heart rate (HR) relationships

Person no	1	2	3	4
Flex-HR 0	101	70	146	122
Flex-HR 1	110	105	142	104
Flex-HR 2	100	103	128	98
Flex-HR 3	93	95	112	97

Table 4. E-exp in percent of E-intake, estimated for different values of Flex-HR.
Flex-HR 0:   HR=20 beats/min
Flex-HR 1:   HR at E-exp= 2 x BMR
Flex-HR 2:   HR at E-exp=3 x BMR
Flex-HR 3:   HR at E-exp=4 x BMR

previous study (ref. 2). At Flex-HR 0. defined as HR equal to 20 beats/min. energy expenditure was estimated only from the E-exp/HR regression line. because recorded HR was always above this Flex-HR value. Table 4 therefore shows that energy expenditure estimation by making use both of HR and body position recordings (Flex-HR 2). is superior to use of heart rate recordings alone (Flex-HR 0).

6) DISCUSSION

In order to establish the energy requirements of various population groups. data on activity and energy expenditure under normal as well s more unusual living conditions are needed. More information on the inter-individual variation in energy expenditure would also be valuable in order to explore the causes of obesity and to establish whether. and to what extent. physical activity is good for human health. as is often postulated (Ref. 4). The need for reliable methods to obtain such information is therefore obvious.

The introduction of the doubly labelled water method for measuring energy expenditure in humans has attracted much attention in the recent years (Ref. 5). The method gives an estimate of the average energy expenditure for the measurement period. usually 10-14 days. and is claimed to have an accuracy of about 5% when properly conducted. The main disadvantage is the high cost of the stable isotopes and mass spectrometric analyses. so that use is economically feasible only on a limited number of persons. Due to the good accuracy. it is the method of choice for validation of alternative techniques for measuring energy expenditure under free-living conditions.

The use of heart rate registrations for estimation of energy expenditure. and the rather disappointing results. has already been pointed out. An alternative approach for obtaining information about activity and energy expenditure is the use of motion sensors. such as accelerometers (Ref. 6). Much effort has been invested in the development and testing of such devices. but there are still remaining limitations and

1) The sensors are not robust and have a high failure rate during field conditions.

2) Each device has its own sensitivity. which makes inter-instrument comparison difficult.

3) It may be difficult to convert the output from such motion sensors into quantitative estimates of energy expenditure.

In contrast to the experience with accelerometers. the Actireg has been robust and functioned properly also during prolonged use by persons with high activity levels.

Since information from the tilt switches is of the on-off type. there is very little inter-instrument variation. and registrations from different devices may be directly compared.

As already mentioned. there are considerable differences in the energy costs of lying. sitting and standing activities.

It is therefore a reasonable assumption that information from Actireg registrations may be of value for estimation of energy expenditure. particularly in combination with heart rate recordings. The results from the first experiments with this new device lends support to this assumption. However. firm conclusions on this point must await the outcome of validation experiments with the doubly labelled water method or measurements in a whole body calorimeter.

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PROTEIN REQUIREMENTS IN HYPOXIA OR HYPOKINESIA

C.Y. GUEZENNEC, A.X. BIGARD, D. TAILLANDIER

Centre d'Etudes et de Recherches de Médecine Aérospatiale
(C.E.R.M.A.) Division de Physiologie Métabolique et Hormonale
C.E.V. - 91228 Brétigny sur Orge (France)

SUMMARY

Protein requirement could be enhanced in two situations involved in aerospace environment which are weightlessness and hypoxia exposure. In order to verify the needs for enhanced protein diet two experiments were conducted.

1) to examine whether or not protein intake is able to limit muscle atrophy in prolonged weightlessness conditions, we studied the effects of a high (30 %, HP) and a medium (15 %, MP) protein intake on protein metabolism in rats after 21 days of hindlimb suspension (HS). Fractional rates of protein synthesis were determined in vivo in the slow twitch dark soleus and fast twitch pale tibialis anterior muscles. A flooding dose method was used for the determination of muscle synthesis rates. In MP rats, 21 days of suspension induced simular significant decreases in fractional rate of protein synthesis (Ks), in the soleus (33 % and tibialis anterior muscles (25 %). By contrast, no significant variations were detected in the soleus of HP rats ; however Ks declined by 24 % in the tibialis anterior. These results demonstrated that a high protein intake may reduce muscle protein wasting in simulated weightlessness conditions, presumably by increasing the efficiency of the translational process.

2) the effects of two levels of protein intake on muscle performance and energy metabolism were studied in humans submitted to repeated daily bouts of prolonged exercise in hypoxia. For this purpose, 29 healty males, were exposed to 7 successive stages of ski-mountaineering at an altitude between 2,500 and 3,800 m and to an isocaloric diet (4,000 kcal.day^{-1}) with either 1.5 g.kg^{-1} day^{-1} (C group, n = 14), or 2.5 g.kg^{-1} .day^{-1} (Pr group, n = 14) protein intake. The peak torque during maximal isometric voluntary contraction (MVC) of the quadriceps muscle was unaffected by the repeated exercises, whereas the endurance time at 50 % MVC was decreased in Pr subjects (- 26.8 %, p < 0.001). The plasma amino acid pattern was altered after completion of the ski-mountaineering programme ; the plasma concentration of the 32 branched-chain amino acids (BCAA) was significantly decreased in C subjects, whereas high levels of protein intake greatly minimized the exercice induced decrease in serum BCAA. These data outlined that increased protein intake, which reduces the alteration in plasma amino acid pattern observed following long duration exercises in altitude, should not be at the expense of carbohydrate load.

INTRODUCTION

Muscle trophicity is under the influence of four major factors which are nutrition, nervous stimulation, muscle activity and hormones. Numerous work have shown that substrate availability acts directly on muscle protein synthesis. The glucidic and proteic substrates regulates in a coordinated way the muscle proteosynthesis. So that the attention was focused on the role of protein nutriment for protect muscle against protein wasting. Several conditions couldq decrease protein body stores among which hypoxia exposure or hypokinesia. This both environmental factors results of aerospace or military events. Two studies were conducted in order to evaluate the role of protein diet on protein metabolism during hypokinesia or hypoxia exposure.

FIRST STUDY EFFECT OF PROTEIN COMPLEMENTATION ON MUSCLE METABOLISM DURING HYPOKINESIA

Weightlessness is associated whith skeletal muscle atrophy and a large decrease in body mass (13), since muscles are the main reservoir of body proteins. These effects and others, like bone modifications, could decrease physical capacity, and may influence flights time and consequently space exploration.

It has been shown for a long time with either spaceflights, or the hindlimb suspension rat model, that weightlessness induce alterations of the mechanical, structura and metabolic properties (9) of muscles, especially in slow twitch i.e. antigravity muscles. The relationships between these metabolic modifications and nutrition are poorly documented. This is particularly unfortunate since spaceflights of several years are planned in the future.

Protein metabolism has yet been studied during ground based simulationf of short term (< 14 days) (9, 11) using various suspension models, techniques of investigation of protein synthesis or breakdown and rat strains, but standard

nutritional conditions. According to these studies, muscle protein wasting results mainly from large increase in proteolysis and from a reduction of protein synthesis. After this adaptative period, there is a curtailment of proteolysis without any change in protein synthesis. This results in a new state of equilibrium (11, 19), where nitrogen balance becomes slowly positive, since muscle growth is again detectable. Therefore, a first goal of this study was to obtain information on protein metabolism when muscle atrophy ceased and concomittant growth of body and muscle has started again. In addition, a single report from Goldspink et al. (9) emphasized the necessity of pair-feeding between suspended and control animals, since suspension technique may affect food intake. Also, protein intake is well known to modulate both protein synthesis and breakdown (21). Consequently a second major aim of this study was to evaluate the effects of protein intake (15 and 30 %) on skeletal muscle protein metabolism under long term suspension, using the appropriate pair-fed control animals.

Materials and methods

Animals

60 mals Wistar rats (Iffa-Credo, l'Arbresles, France) with an average body weight of 150 g were used for all investigations and randomly distributed into control (CT) and suspended (HS) group. HS rats were suspended by the tail according to a slightly modified MoreyHolton's protocol. All animals were maintained in a temperature-controlled room (22 ± 1°C) with a 12-h light : dark cycle. The experiments were carried out according to French laws ans regulations which are in accordance with the NIH guide for care and use of laboratory animals.

Diets

Two diets were tested to study the effect of protein intake on protein turnover, i.e. a semi-liquid diet with 15 % protein (MP rats), or with 30 % protein (HP rats). They consisted of Norway Kaplan hering flow (Lorientaise Produit de Pêche, Lorient, France) and starch (Louis François, St Maur, France).

Animal and muscle growth

Two groups of 10 MP and 10 HP suspended rats were gradually sacrified after 18 to 24 days of suspension in order to measure muscle growth around the suspension time used in other investigations (21 days). Ten MP and 10 HP pair-fed CT rats were also sacrificed during an identical time-course.

Protein turnover

Twenty rats were randomly divided into 4 groups, i.e. CT-MP, HS-MP, CT-HP and HS-HP. The fractional rate of protein synthesis was determined in the soleus and tibialis anterior muscles after 21 days of treatment or of hindlimb suspension by the large dose methode of Goldspink (9) for this model ; animals received sub-cutaneously an injection of 2.5 ml L-[2-3-4-^{3}H] valine (CEA, Saclay, France) combined with L-valine (Merck, Darmstadt, Germany)(130 mmol/ml, 1.44.10^9 dpm/ml). In each group, 5 rats were killed by cervical dislocation 10, 15, 20, 25 and 30 minutes after the injection. Blood collected at that time was immediately centrifuged at + 4°C and plasma was frozen in liquid nitrogen.

Protein turnover

The fractional rate of protein synthesis (Ks) was calculated from the equation Ks (100.Sb)/Sa-t, where Sb is the specific radioactivity of protein-bound valine, and Sa the specific radioactivity of free valine at to. The fractional rate of muscle protein growth (Kg) was calculated time in days. The fractional rate of muscle protein growth (Kg) was calculated as the percentage of protein mass gained daily over the last 4 days of experiment. Since the muscle/body weight ratio was constant at that time (data not shown), Kg was calculated between day 18 and 21 of experiment using linear regressions of muscle weight vs. body weight. The fractional rate of protein degradation (Kd) was calculated as the difference between Ks and Kg.

Statistical analysis

All results are expressed as means ± SE. The effects of treatments were

evaluated by analyses of covariance and variance, using the SAS software (SAS 1988, SAS institute Inc. Cary, NC).

Results

Animal growth

Food intake of the rats sharply decreased by 30 % during the first two days of suspension for both diets. This immediately resulted in a reduction of growth rate in HS ans pair-fed CT rats, weight gain beeing 0.29 ± 0.78 ans -3.21 ± 0.80 g.d^{-1} ($p < 0.001$) respectively. Thereafter, food intake of HS rats slowly increased, and reached a plateau after 8 days, of suspension until the end of the experiment.

Muscle growth (Tables 1, 2)

Suspension induced muscle atrophy according to the muscle metabolic and contractile type. No significant difference was observed between muscles from MP and HP rats.

TABLE 1 : Effect of 21 days hindlimb suspension on soleus and tibialis anterior muscles growth in rats fed the 15 % protein diet (MP)

	SOLEUS		TIBIALIS ANTERIOR	
	CT	HS	CT	HS
Mucle mass (mg)	215 ± 32	$75 \pm 18^*$	1127 ± 139	$918 \pm 116^*$
Muscle/whole body (mg/g)	72 ± 8	$28 \pm 6^*$	378 ± 40	$348 \pm 25^*$
Total RNA content (µg)	167 ± 25	$64 \pm 15^*$	731 ± 14	647 ± 128
Total protein content (mg)	11.3 ± 1.08	$4.2 \pm 1.2^*$	207 ± 21	189 ± 14

Values are means ± SE for 20 rats * : $P < 0.001$ for suspended (HS) vs controls (CT) animals

TABLE 2 : Effect of 21 days hindlimb suspension on soleus and tibialis anterior muscles growth in rats fed the 30 % protein diet (HP)

	SOLEUS		TIBIALIS ANTERIOR	
	CT	HS	CT	HS
Mucle mass (mg)	219 ± 37	$73 \pm 15^*$	1127 ± 120	$957 \pm 88^*$
Muscle/whole body (mg/g)	75 ± 9	$26 \pm 4^*$	385 ± 24	$354 \pm 23^*$
Total RNA content (µg)	245 ± 46	$37 \pm 3^*$	937 ± 136	$618 \pm 140^*$
Total protein content (mg)	12.4 ± 1.4	$4.2 \pm 0.3^*$	220 ± 21	$175 \pm 12^*$

Protein turnover (Tables 3, 4)

Sub-cutaneous injection of a flooding dose of labeled amino acid was used for the first time in this study. In MP rats, suspension reduced protein synthesis (Ks) by 33 % ($p < 0.001$) and 25 % ($p < 0.003$) in the soleus and tibialis anterior muscles respectively (table 3). In HP rats, the reduction in Ks was non significant in the soleus muscle but was still apparent (24 %) in the tibialis anterior. The muscle protein growth (Kg) was reduced by 23 % (soleus) and 22 % (tibialis anterior) in MP rats, but it only diminished by 11 and 3 % in HP animals compared to their pair-fed controls. With the HP diet, there was no significant decrease in Kd of the soleus muscle after suspension, whereas Kd fell by 24 % in the tibialis anterior muscle.

The efficience of protein synthesis (K_{RNA}) in the soleus and tibialis anterior muscles was diminished by suspension (30 and 39 % respectively, $p < 0.05$) in MP rats, but increased (96 %, $p < 0.001$ and 27 % respectively) in HP animals. Compared to CT-MP rats, K_{RNA} of CT-HP was lower by 26 and 35 % in the soleus and tibialis anterior muscles respectively.

TABLE 3 : Protein turnover in soleus and tibialis anterior muscles after 21 days of suspension in rats fed the 15 % protein diet (MP)

	SOLEUS		TIBIALIS ANTERIOR	
	CT	HS	CT	HS
Ks, %/day	10.8 ± 0.36	$7.3 \pm 0.40^*$	7 ± 0.32	$5.3 \pm 0.36^{**}$
Kg, %/day	2.3 ± 0.20	1.8 ± 0.21	2.7 ± 0.23	2.1 ± 0.26
Kd, %/day	8.5 ± 0.30	$5.5 \pm 0.33^*$	4.3 ± 0.38	$3.1 \pm 0.42^*$
Ks/Kd	1.3 ± 0.05	1.3 ± 0.09	1.7 ± 0.33	1.6 ± 0.15
K_{RNA}, mg prot synthezised/day/mg/RNA	28.4 ± 3.1	$19.8 \pm 1.0^*$	46.4 ± 5.3	$28.4 \pm 2.3^*$

TABLE 4 : Protein turnover in soleus and tibialis anterior muscles after 21 days of suspension in rats fed the 30 % protein diet (HP)

	SOLEUS		TIBIALIS ANTERIOR	
	CT	HS	CT	HS
Ks, %/day	9 ± 0.40	8.2 ± 0.36	5.73 ± 0.38	$4.34 \pm 0.36^{**}$
Kg, %/day	1.6 ± 0.22	1.4 ± 0.20	1.73 ± 0.23	1.68 ± 0.23
Kd, %/day	7.50 ± 0.33	6.7 ± 0.30	3.85 ± 0.42	$2.66 \pm 0.38^*$
Ks/Kd	1.2 ± 0.04	1.2 ± 0.09	1.49 ± 0.12	1.63 ± 0.34
K_{RNA}, mg prot. synthezised/day/mg/RNA	18.4 ± 3.5	$36.2 \pm 0.3\#$	30.0 ± 4.3	$38.40 \pm 4.3^*$

Values are means ± SEM for n = 5 rats * $P < 0.05$, with respect to control (CT)
** $P < 0.002$
$\#$ $P < 0.001$

Discussion

There is only very limited information on skeletal muscle protein turnover during long-term simulated weightlessness. Indeed, only one study addressed this question indirectly. Thomason et al. (19) reported that the soleus muscle myofibril protein content underwent a rapid decrease within the first two weeks following suspension, and then stabilized suggesting an adaptative mechanism.

We showed here that after 3 weeks of suspension, a positive nitrogen balance was already achieved in both antigravity muscles (i.e. soleus) and phasic muscles (i.e. tibialis anterior). The factors responsible for the transition from a net catabolic state in skeletal muscles during short-term suspension to a small but positive net anabolic state after 3 weeks of treatment are still unclear. It is likely that the reduction in protein synthesis rates observed within a few hours or days (9) after hindlimb suspension results primarily from stress and disuse.

These data suggest that during long-term simulated weightlessness both protein synthesis and breakdown influenced protein balance to the same extent. This was clearly different from short-term suspension effects, when proteolysis mainly regulates muscle protein balance.

In man and other mammals the nutritional factof which has the most important influence on protein turnover is protein intake (21). Since additionally skeletal muscle protein synthesis is more sensitive to dietary restrictions than any other tissue even small differences in food intake might obscure the effect of weightlessness on muscle protein metabolism (9). Indeed, food intake was first depressed during approximately one week following hypokinesia and hypodynamia and secondstabilized thereafter, without any significant increase as should occur in these young growing rats.

Our data first demonstrated that protein intake influenced skeletal muscle protein turnover through different mechanisms in control and suspended rats. In control animals, protein fractional synthesis rates decreases when protein intake increases. Keeping in mind that the MP diet ensures maximal growth in rats, these observations are consistent with previous reports that protein intake at levels greater than required for maximal growth results in a decrease in both whole-body and skeletal muscle protein synthesis (22). We showed here that the reduction in protein synthesis occured through an inhibition of the ribosomal efficiency (K_{RNA}) although ribosomal capacity increased. By contrast, increasing protein intake in suspended animals prevent the decrease in Ks through and increase in K_{RNA}. These data suggest that when activity is reduced either by disuse as in the present experiment, atrophying muscles became more sensitive to stimuli known to modulate protein synthesis than control muscles. In both cases this response seemed to improve primarily the efficiency of the translational process. In addition, these adaptations were more efficient in the suspended soleus than in phasic muscles which differ from soleus with respect to hormonal sensitivity, contractile and metabolic properties.

In conclusion, our data clearly demonstrate that protein intake in excess of that required for maximal growth was able to delay protein muscle atrophy during prolonged weightlessness conditions. This effect occured presumably at the translational level and was particularly efficient in slow-twich type fiber muscles, i.e. in muscles which undergo pronounced muscle protein wasting in these conditions. This suggests that high protein intake may be combined with other treatments (i.e. hormonal, training...) to limit muscle protein wasting in these catabolic conditions.

SECOND STUDY

It is now well-established that protein metabolism is markedly altered in response to endurance exercise, and that only few amino acids could contribute to energy production (10). This increase in amino acid catabolism is offset by an increase in the availability of amino acids in the free amino acid pool. The size of this pool strongly depends on the rates of protein synthesis and/or protein degradation.

Long term exposure to high altitude is known to affect body weight. In the past, this weight loss was attributed to reduction in body fat (4), loss of lean body mas, or dehydration. Recent data showed that prolonged exposure to high altitude reduced the carbohydrate preference observed during the first time of the sojourn (16). However, we could expect that a shorter sojourn at moderate altitude (< 4 000 m) has less effect on body composition.

All these results raise the question of increased protein requirements for well-trained subjects performing repeated daily bouts of prolonged exercise at moderate altitude. Repeated exercise of long duration is known to induce progressive muscle glycogen depletion, whereas altitude induces anorexia and changes in dietary preference. All these factors should lead to an alteration of the br-^-hed chain amino acid degradation (BCAA), the BCAA an preferentially used during exercise.

The purpose of this study was to test the exercise performance, and the modifications in plasma amino acid pattern and energy metabolism, induced by repeated prolonged exercise performed at moderate altitude, in male subjects submitted to two levels of dietary protein intakes. In order to minimize the altered protein metabolism expected to follow repeated daily bouts of prolonged exercise in moderate altitude, we tested the effects of a high-protein diet.

Material and methods

Subjects

29 healty males gave their informed consent to participate in this study. All were highly trained to prolonged exercise and had been ski mountaineering for many years. Subjects participated in 7 successive stages of ski mountaineering, each separated from the following by a night in a refuge. Each exercise bout consisted of 7 to 11 h of walking on skis. The energy cost of this exercise was increased by the load carried by hikers (backpack 15-20 kg).Each stage took place at an altitude between 2,500 and 3,800 m, and represented a daily ascent warying between 800 and 1,300 m.

Dietary protocol

Subjects were randomly assigned to 1 of 2 treatment groups : a control protein diet group (C, n = 14), and an enriched protein diet group (PR, n = 15). The total energy intake was estimated to 4,000 kcal.day^{-1}. The C diet consisted in approximately 60 % carbohydrate, 28 % fat, and 12 % protein (1.5 g.kg^{-1}.day^{-1}), whereas PR subjects consumed a high-protein diet (2.5 g.kg^{-1}.day^{-1}). In the PR group, the additional nitrogen was supplied by commercial protein supplement which consisted of casein.

Prior to the diet phase of the study, and immediately after completion of the ski mountaineering programme, the percentage of body fat (%BF) of all subjects was measured using near-infrared interactance.

Exercise capacity determination

During the 2 days prior to the ski-mountaineering programme, the maximal oxygen uptake (VO$_2$ max) was determined by a direct method using an open system to analyse the expired gases (Beckman Horizon MMC, Beckman Instruments, Anaheim, California, USA). Subjects performed an exercise on a cycle ergometer (Ergomeca, SOREM, Toulon, France) according to an incremental protocol.

Peak torque during maximal voluntary isometric contraction (MVC) of the quadricepts muscle was measured on the right leg of each subject. Subjects sat confortably in an adjustable chair and measurements were made during isometric leg extension on an isokinetic dynamometer (Cybex II equipment, Cybex Division of Lumex INC, Ronkonkoma, NY, USA). Following a sufficient recovery period, the endurance time at 50 % MVC was measured on the same leg and in the same knee position.

Plasma amino acid concentrations were determined on half the subjects (PR group n = 6) as follows : plasma samples (5 ml) were mixed with an equal volume of 10 % trichloracetic acid (TCA) and kept in ice for 20 min before centrifugation (1,500 g for 15 min.). Supernatants were desalted on 8 ml Dowex 50X8 (100-200 mesh ; H$^+$ form). Amino acids were eluted with 4 M NH$_4$OH, taken to dryness under reduced pressure, and dissolved in 2 ml lithium citrate buffer (pH = 2.2). After homogenization in 10 % TCA, plasma samples were treated with an automatic amino acid analyzer (LKB 4151 Alpha plus, LKB, Cambridge, UK). L-norleucine was used as internal standard.

Statistical procedures

Experimental data were analysed using a paired Students't test An alpha level of P < 0.05 was selected to indicate significant differences between values recorded during pre-, and post-ski mountaineering programme.

RESULTS

Body weight and body composition

The completion of 7 ski-mountaineering stages was without effect on body weight, both in group C (+ 0.46 %, NS) and in group PR (- 0.79 %)(Table 5). % BF was significantly decreased by the ski programme in PR subjects with an average loss of 2.02 % (p < 0.001), whereas % BF pf subjects from C group was unaffected by the repeated exercices (- 0.52 %, NS).

Exercise capacity

The ski-mountaineering programme did not modify VO$_2$ max level, neither in C nor in PR subjects (Table 5). After 7 days of ski mountaineering, heart rate (HR) measured at VO$_2$ max level was decreased in both C (- 3.2 %, p < 0.001) and PR subjects (- 3.4 %, p < 0.001). The mVC of the quadriceps muscle was unaffected by the repeated ski exercise (figure 1). However, the endurance time of the quadriceps muscle at 50 % MVC was dramatically reduced in PR subjects after dynamic skiing : - 26.8 %, p < 0.001 in PR subjects, versus - 9 %, NS in C subjects (Figure 1).

	C group (n = 14)	PR group (n = 15)
Body weight, kg		
Pre	71.11 ± 3.37	70.95 ± 2.75
Post	71.44 ± 3.40	70.39 ± 2.37
Percentage of Body fat		
Pre	9.23 ± 0.89	9.66 ± 0.85
Post	8.71 ± 0.71	7.64 ± 0.67 a
VO2 max (ml/min.kg)		
Pre	53.56 ± 1.40	54.42 ± 1.07
Post	53.65 ± 1.33	52.14 ± 0.77
RER ratio at VO2 max		
Pre	1.18 ± 0.01	1.17 ± 0.01
Post	1.18 ± 0.01	1.16 ± 0.01
HR at VO2 max (bpm)		
Pre	186 ± 1.95	178 ± 3.01
Post	180 ± 1.92 c	172 ± 3.53 c

Table 5 : Body weight, body fat variations, and parameters of exercise capacity in relation to repeated long-term exercise (pre, post), and dietary composition.

Values are means ± SEM
Significantly different from pre-exercise values :
a P < 0.05 ; b P < 0.01 ; c P < 0.001

Peak torque during isometric contraction

☐ PR group ▨ C group

N.m (y-axis: 0, 100, 200, 300)

Pre   Post
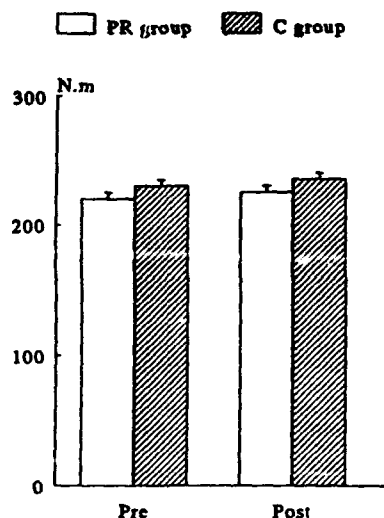
Endurance time at 50% of peak torque

☐ PR group ▨ C group
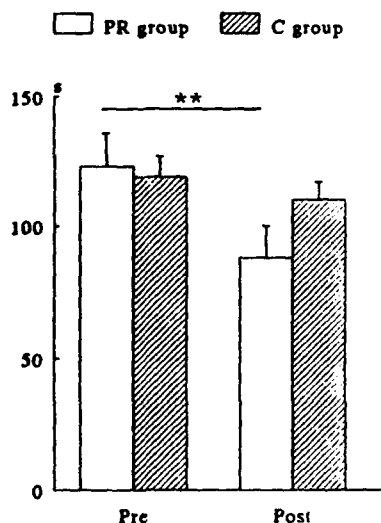

s (y-axis: 0, 50, 100, 150) **

Pre   Post

FIGURE 1 : Peak torque during maximal isometric voluntary contraction, and endurance time of the quadriceps muscle at 50 % of MVC, before (pre) and after (post) repeated daily bouts of endurance exercise.

Plasma amino acid pattern

The concentrations of free amino acids in plasma estimated at rest before and after ski training, are summarized in Table 6. Plasma concentrations of the 3 BCAA (Branched Chain Amino Acids) were significantly decreased by the dynamic-skiing programme in C subjects : leucine (- 18 %, $p < 0.001$), isoleucine- 14 %, $p < 0.05$), valine (- %% %, $p < 0.001$). The subjects who consumed the high-protein diet did not exhibit significant changes in plasma BCAA levels. Except for histidine, which decreased in both C and PR subjects (respectively - 9.9 %, $p < 0.05$, and - 18.7 %, $p < 0.001$), essential amino acids were unaffected by the repeated exercises. On the other hand, plasma levels of other amino acids which are known to provide amino groups transaminated to pyruvate in order to form alanine, appeared to be unchanged by the 7 days of skin mountaineering. This was observed in both C and PR subjects. However, glutamate concentration, an amino acid which is oxidized in skeletal muscle, was raised by + 33 % in C group (p < 0.001). Plasma concentration of alanine, an amino acid which plays a key-role during muscular exercise appears to be unchanged by the repeated ski stages.

	C group (n = 6)	PR group (n = 6)
LEUCINE		
Pre	14.63 ± 1.54	14.38 ± 1.62
Post	11.33 ± 1.04 c	12.39 ± 2.08
ISOLEUCINE		
Pre	7.76 ± 1.09	7.41 ± 0.97
Post	6.55 ± 1.16 a	6.42 ± 01.31
VALINE		
Pre	26.91 ± 2.43	26.13 ± 2.62
Post	19.81 ± 1.74 c	21.64 ± 3.77
ASPARTATE		
Pre	0.99 ± 0.24	0.92 ± 0.15
Post	0.88 ± 0.13	0.91 ± 0.11
ASPARAGINE		
Pre	7.44 ± 0.96	6.97 ± 0.96
Post	7.38 ± 1.05	6.22 ± 0.53
ALANINE		
Pre	35.62 ± 5.01	32.26 ± 8.25
Post	37.78 ± 6.05	27.04 ± 2.33

Table 6 : Plasma amino acid concentrations in relation to repeated long-term exercise (pre, post), and dietary composition.

Values are expressed as $\mu M/100$ ml

$a\ P < 0.05 ; c\ P < 0.001$

DISCUSSION

Results presented in this study following 7 stages of ski mountaineering suggest that the high-protein diet (casein supplement providing a daily protein intake of 2.5 $g.kg^{-1}$) induced % BF loss, and reduced the endurance time of the quadriceps femoris muscle in a knee extension test. However, the plasma amino acids pattern of C subjects dramaticcaly differed from basal values, whereas a non significantly different value was observed in subjects who ingested the high-protein diet.

The effects of a high level of protein intake on % BF remain controversial. Although previous studies did not show any significant variation in % BF[18], Consolazio et al. (6) confirmed that chronic exercise at high intensity induces a significant decrease in body fat. However, results showed that subjects consuming high-protein diet (2.8 $g.kg^{-1}.day^{-1}$) significantly increased their lean body mass, with an expected % BF loss. Under our conditions, the overall decrease in % BF observed in all subjects (p < 0.001 and NS for PR and C subjects, respectively) is in accordance with the expected specific effects of moderate altitude exposure (4). However, since body weight was unchanged, it seems possible to hypothesize that high-protein diet raises % BF loss.

After completion of the 7 ski mountaineering stages, subject's exercise capacity was only altered in PR group with reduced quadriceps endurance. These data corroborate those reported by Walberg et al. (20) who evidenced a significant decrease in quadriceps endurance in weight lifters after they were submitted to a high-protein/moderate-carbohydrate diet (two times the RDA for protein, and 50 % carbohydrate). Several hypothesis may be considered in order to explain this reduced endurance time. First, a progressive muscle glycogen depletion in the PR group, due to the repetition of daily bouts of prolonged exercise and to the consumption of a reduced-carbohydrate diet which contributes to altered glycogen resynthesis (1). Although muscle glycogen concentrations were not measured in our study, it is legitimate to suggest that reduced quadriceps endurance capacity observed in PR group was partly explained by an alteration of muscle glycogen availability.

One of the main results of this study, is the profound alteration of the plasma amino acid pattern observed in subjects of group C after they had completed the 7 ski-mountaineering stages. Christensen (5) has emphasized that alteration of the plasma amino acid pattern represents one information on protein metabolism. However, the lack of data on amino acid flux does not allow strict interpretations concerning, for instance, hepatic neoglucogenesis or protein breackdown. Nevertheless, our results confirm that repeated daily bouts of exercises of long duration reduce plasma concentrations of BCAA in subjects submitted to a control diet. This decrease appears to be marked, especially as plasma concentrations were measured 12 h after subjects had completed the ski-mountaineering programme. These data agree with those reported by Blomstrand et al. (2, 3) during a marathon race, and with those reported by Decombaz et al. (8) and Stein et al. (17) after exercises of longer duration (100 km run and 8 h of bicycling and running). Thus, reduced plasma concentration of BCAA could be mainly due to their enhanced oxidation rate in skeletal muscle. It is now well-known that endurance exercise promotes

catabolism of BCAA at an increased rate, and this uniquely in skeletal muscle (10). The role of moderate-altitude exposure on the alteration of BCAA plasma levels can be descussed. There are very few data available on energy metabolism at moderate altitude. Most studies have been focused on body composition changes and nutrition alteration occuring at high (> 4,000 m) or extreme altitude (> 6,500 m). Under these experimental conditions, several studies hve evidenced a change in dietary preference with a shift from fat and protein to carbohydrate intakes (4, 7). On the other hand, decreased intestinal absorption of both fat and carbohydrate was shown to occur at high altitude (below 5,400 m)(4). All these data were observed during studies performed at altitudes up to 5,400 m, and it seems reasonable to expect smaller changes during exposure at moderate altitude (> 3,800 m). However, although under our experimental conditions, subjects hiked at altitudes between 2,500 and 3,800 m, we can not rule out a role of decreased protein intake (due to lesser protein preference) or to intestinal malabsorption as factors enhancing protein catabolism during long duration exercise.

However, it appears that a high-protein diet reduces the decreased plasma concentration of BCAA. In PR subjects, a trend toward decreased plasma BCAA was observed, but without statistical significance. The effects of the use of high levels of protein intake on protein metabolism were well-investigated under catabolic conditions such as injury (for rev. see Kinney and Elwin (12)). More recently, the effects of BCAA supplementation counteracted the exercise-induced decrease in BCAA plasma levels, and at best increased them, especially after a marathon race. On the other hand, these authors evidenced a significant increase in physical performance in marathon runners who consumed BCAA supplement during exercise. Thus, the role of BCAA supplement on performance improvement might be questioned. In our study, plasma glutamine level, an amino acid which plays a critical role for elimination of ammonia from urine, appears to be unchanged after exercise in both C and PR subjects. These data are consistent with the results of Stein et al. (17) who showed that glutamine concentration was unaffected by 8 h of endurance exercise. The serum alanine concentration decreased during, and immediately after an exercise of long duration (8). However, this exercise-induced alteration of plasma alanine appears to be transient since Decombaz et al (8) have clearly shown that alanine had practically recovered its pre-run value 24 h after the end of a 100 km race. This could explain the lack of changes in serum alanine level observed in our study.

In summary, results obtained following 7 consecutive ski-mountaineering stages representing repeated exercises of long duration (an average of 8-9 h daily exercise), at moderate altitude :
- suggest that a like at sea-level, repeated daily bouts of exercise of long duration at altitude, induce a significant alteration of the pattern of plasma amino acids. BCAA were mainly affected by the physical activity of high intensity and long duration, and were reduced by -14 to -22 % at rest, in subjects who consumed a control diet,
- emphasize the fact that high-protein diet (2.5 g.kg^{-1}.day^{-1}) minimizes the exercise-induced decrease in BCAA plasma level,
- confirm that, in order to maintain muscle performance, the increased protein intake should not be at the expense of the carbohydrate load.

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NUTRITION FOR A TYPICAL MAC CREW DURING DESERT STORM

J. French[1]
T.J. Cook[2]

[1]Sustained Operations Branch, Armstrong Laboratory
Brooks AFB, TX 78235-5000

[2]Internal Medicine Branch, Armstrong Laboratory
Brooks AFB, TX 78235-5301

USA

SUMMARY

Data on inflight meals were collected during a 30-day field experiment conducted by the Armstrong Laboratory designed to evaluate fatigue in C-141 Military Airlift Command (MAC) aircrew. Flight meal information was collected for one five-member crew throughout the area of operation during the last week of Desert Storm and for 3 additional weeks. This paper focuses on the nutritional components of a representative sample of the inflight meals provided to MAC aircrew. Nutritional analysis was based on fifteen inflight meals obtained from various Desert Storm staging bases. Analysis concerned kilocalories, protein, carbohydrate, fat, cholesterol, sodium and saturated fats present in the average meal. The mean value for these components, constituting an average inflight meal, were 1758 Kcal, 53 g protein, 233 g carbohydrate, 66 g fat, 136 mg cholesterol, 3240 mg sodium and 20 g saturated fats. The limitations of this opportunistic evaluation and the need for additional field analyses of inflight meals and aircrew diets is discussed.

1 INTRODUCTION

Military Airlift Command (MAC) flew supply missions from the United States to bases in Saudi Arabia at an unprecedented pace beginning in August of 1990 and throughout Operations Desert Shield and Desert Storm. The 7000 mile air bridge, operating 24 hours a day, was the largest undertaking of its kind in history. The magnitude of the effort is suggested by the fact that in 6 weeks, the tonnage carried exceeded that during the entire 1945-46 Berlin Airlift. The rapid onset and prolonged duration of the MAC operations produced erratic lifestyle conditions for the aircrews. Also, the support agencies for operations of this size, for example, aircraft maintenance, security, and flight kitchens, were stressed to match the heightened supply efforts. This paper focuses on the nutritional adequacy of the inflight meals supplied to MAC aircrews during the accelerated conditions of Desert Storm.

The importance of adequate nutrition is emphasized by the fact that poor diets can be a factor in the etiology of some diseases as well as physical and mental fatigue (1). The opportunity to evaluate nutritional quality of typical inflight meals supplied to aircrews occurred during a large scale evaluation of fatigue in MAC aircrew during Desert Storm. This paper attends to only the nutritional aspects of flight meals. Aircrew fatigue evaluations are reported elsewhere in this symposium. The inflight box meal was often the most important source of nutrition for aircrew particularly during long (20-hour) duty days. Current aircraft, in this case the C-141, do not carry adequate cold storage or heating facilities to provide for high quality meals. Accordingly, flight meals must have low perishability as well as the required high protein and low residue content (2). Such restrictions often reduce the variety of the typical flight meal (3). However, because of their long and atypical work hours the nutrition supplied to aircrews is essential to maintain performance at peak efficiency. Consequently, the nutritional quality of the meals provided by major staging bases to a "typical" C-141 airlift crew in the Gulf theater of operations were investigated.

2 METHODS

Investigators from Armstrong Laboratory accompanied five MAC C-141 crews throughout a 30 day study, collecting data on temperature, mood, sleep patterns, and flying performance. This study is based upon data collected by the first author who recorded contents of the meals prepared for the crew that he accompanied. The data consisted of each item in fifteen meals which were purchased by the majority of the crew at each facility throughout the study. The dietary record was kept in a log book and is provided in its entirety in Appendix 1. The crew of five men were between 22-31 years of age, with an average age of 27.6 years; these men weighed between 155-215 lbs., with an average weight of 172.4 lbs.; they were between 68-78 inches tall, with an average height of 71.8 inches. The flights were flown between 16 March and 14 April, 1991. Box meals are usually prepared by local flight kitchens at the base of departure and consumed by aircrew during flight.

The evaluation began by confirming the portion sizes (and some of the ingredients) found in the dietary record. The flight kitchens were contacted at the MAC bases that supplied the meals and portion sizes were corrected. The nutritional components of greatest interest to MAC were communicated by the USAF Medical Center at Scott AFB, Illinois. Nutritional analysis of the one Meal-Ready-to-Eat (MRE) was obtained from the U.S. Army Natick Research, Development and Engineering Center, Natick, Massachusetts. Nutritional analysis was further aided by the *Nutritionist III* computer program (N-Squared Computing, Salem, Oregon 1990), the *Bowes and Church's Food Values For Portions Commonly Used* handbook (4), and from information supplied by manufacturers of several brand name items in the meals.

Nutritional analyses of the dietary record focused on seven nutrients: total kilocalories, protein, carbohydrate, fat, cholesterol, sodium and saturated fat. These particular components were selected because they are emphasized both within current health promotion efforts (Healthy Heart program) and with ongoing studies of interest to the Air Force Chief of Staff. An average from all fifteen

lunches was obtained and compared to the standards of the Military Recommended Dietary Allowances (MRDA) according to Air Force Regulation 160-95 (5). A percentage was then determined to evaluate the nutritional content of the average boxed meal compared to the MRDA. Standard calculations were used to determine the gram equivalent required for carbohydrates, fats and sodium based on percentage kilocalories of each. For example, the MRDA for carbohydrates were set at 55% of kilocaloric intake, the MRDA recommendation for which is 3200. The 4 kilocalories per gram of carbohydrates provided the resulting ratio value used for this component. Similarly, the MRDA for fat is set at no more than 35% of kilocaloric intake and the final figure was based on 9 kilocalories per gram of fat. The figures for sodium were based on the MRDA of 1700 milligrams per 1000 kilocalories.

Since the MRDA are the standards for military menu planning, they were used for a comparison of the food provided from the fifteen meals. However, since the recommendations for adult civilian dietary information might also be used for comparison, this information is provided in Table 1. Comparison between the MRDA and the General Minimum Recommended Dietary Allowance (RDA) in Table 1, reveal all components but carbohydrates are slightly higher for the MRDA.

Table 1: Recommended Military and Civilian Nutritional Components

	Military RDA	General RDA
KILOCALORIES	3200 Kcal	2900 Kcal
PROTEIN	100 g	63 g
*CARBOHYDRATE	440 g	446 g
*FAT	124 g	96 g
*SODIUM	5440 mg	<2400 mg

* Derived from kilocalories consumed daily.
Note. No military recommendations exist for cholesterol or saturated fats.

The MRDA was taken from the Military Recommended Dietary Allowances (MRDA), AF Regulation 160-95 (5). The information for the General RDA was obtained from *Recommended Dietary Allowances*, National Academy of Sciences (6).

3 RESULTS

Of the fifteen meals that were recorded only one of them was a MRE prepackaged meal. As Appendix 1 shows, four meals were prepared at Zaragoza AB, Spain, three at Charleston AFB, South Carolina, three at King Faud, Saudi Arabia, three more at Frankfurt, Germany, one at Travis AFB, California, and one was prepared at Riyadh, Saudi Arabia.

Nutritional analysis of each of the boxed meals permitted estimating quantities for each of the seven nutritional components of interest. Individual values were averaged for each component to arrive at an approximation for the average nutritional content of "typical" inflight meals provided these MAC aircrew during Desert Storm. Table 2 represents the list of these seven averages.

A proportion was derived for the average meal compared to the MRDA standard and the general civilian RDA. Table 3 shows that the average meal represents over 50% of the MRDA and substantially more of the civilian RDA. Since the

flight meal is intended to be 33% of the nutritional intake, these results indicate that the box meal accounted for more than half of the recommended daily nutrition for these aircrew.

Finally, a breakdown of the nutritional components by location is shown in Table 4. The average values shown for protein, carbohydrates and fat in Table 4 represent the percent of kilocalories (Kcal) derived from each component based on the number of meals (N) at each location.

Table 3: Contents of the Average Boxed Meal Based on the Military RDA and Civilian RDA For Selected Nutritional Components.

	MRDA	RDA
KILOCALORIES	54%	60%
PROTEIN	53%	85%
CARBOHYDRATES	53%	52%
FAT	53%	69%
SODIUM	59%	135%

Table 2: Averages of Selected Nutritional Components for a typical aircrew box meal.

KILOCALORIES	1758 Kcal
PROTEIN	53 g
CARBOHYDRATES	233 g
FAT	66 g
CHOLESTEROL	136 mg
SATURATED FAT	20 g
SODIUM	3240 mg

Table 4: Percent of kilocalories (Kcal) derived from each nutritional component by location.

	Kcal	Protein	Carbohydrate	Fat
Charleston AFB (N=3)	1771	12%	53%	34%
Travis AFB (N=1)	1132	14%	48%	38%
Zaragoza AFB (N=4)	1176	13%	45%	41%
Rhein-Main AFB (N=3)	1509	8%	74%	17%
Saudi Arabia (N=4)	1783	9%	59%	31%

4 DISCUSSION

The boxed meal is intended to represent one of three balanced meals consumed over a twenty-hour period, the maximum length of a duty day for Air Force aircrew. Oftentimes, the boxed meals described herein had to sustain aircrew for twenty-hour duty days. Consequently, these meals were often the principal source of nutrition for the crew. Many times the crews would bring extra food with them but these were often unwise nutritionally consisting primarily of snack foods high in simple carbohydrates, salt and saturated fats. However, it was found that, of the recommended dietary intake, the boxed meals provided approximately 55% of the kilocalories, including 54% of the protein, 53% of the carbohydrates, 54% of the fat, 60% of the sodium, and 41% of the potassium.

Due to the rigorous demands of the flying schedules maintained by MAC, nutritionally sound meals (which are supposed to compose the other two-thirds of the daily intake) were extremely hard to find. Crews often landed odd hours when base food services and local restaurants were closed or offered limited selections. Frequently, all that was available were unbalanced meals from fast food outlets or alcoholic beverages from local clubs and bars. A conscientious study which focuses on the nutritional needs of the aircrew and the meals available in a theater of operations, needs to be conducted on a larger scale than was possible in this opportunistic small sample. It would be important to consider the food available to MAC crews from restaurants and vending machines in addition to flight kitchens. Such a study could also determine the extent of nutritional knowledge of crews. Recommendations from such a study would go far to maintain crews at optimal efficiency. Crews should be continually reminded of healthy eating habits through educational pamphlets, perhaps inserted in the meals. A wider variety of foods could be available if cold storage facilities could be maintained on long range aircraft. Also, cooking facilities that work would improve the palatability of some foods and extend the variety available. Fewer than 7 of the 20 aircraft flown during the 4 weeks of this study had working convection ovens.

It should be emphasized that all bases did their best to provide nutritionally adequate meals. However, bases operating from the same guidelines and with access to a variety of excellent food suppliers had widely different levels of aircrew satisfaction. Some base menus provided a wide range of healthy foods, and their meals were prepared with great pride. Inflight meals could be improved, but our experience demonstrated that the primary deficiency at the staging bases was access to balanced nutrition at all hours of the day during continuous operations. Nutritional support of aircrew must include constant education and training for the aircrew members, but certainly, flight surgeons need to emphasize this important aspect of aeromedical support more frequently. Nutritionists and food service personnel who select and prepare menus for inflight dining may need to concern themselves more with some of these education and training responsibilities.

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Appendix 1

Boxed Meal Contents During Desert Storm.

18 March (Charleston, South Carolina)
2 choices:
1.) chef salad, peanut butter sandwich
2.) pasta, turkey sandwich
Both Meals Had:
crackers, orange juice, milk, pudding, granola bar, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup.

20 March (Zaragoza, Spain)
2 peanut butter sandwiches, roast beef sandwich (all sandwiches were on white bread), 5 crackers, 2 apple juices
(200 ml each; 35% fruit), apple, orange, 2 oatmeal cookies, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup.

21 March (Riyadh, Saudi Arabia)
Ham or turkey on a sesame seed bun, very small salad, fried eggroll, milk chocolate candy bar, orange soda, orange drink, orange, piece of vanilla cake, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup.

22 March (King Faud, Saudi Arabia)
Turkey sandwich (on white bread), Pepsi, 2 apple juices, cherry danish, chocolate chip granola bar, banana pudding, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup

28 March (Travis, California)
Turkey sandwich (wheat bread), pasta salad, 4 saltine crackers, trail mix, mixed fruit can (4.5 oz.; light syrup), milk (0.5 pint; 2% milkfat), apple juice (6 oz.; 100% fruit juice), danish pastry with apple center (1.75 oz.), lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup.

29 March (Zaragoza, Spain)
Roast beef sandwich (on white bread), ham and cheese sandwich (on white bread), cherry drink, orange drink, apple, orange, peanut butter cup, 2 pecan sandies, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup.

31 March (King Faud, Saudi Arabia)
MRE dinner: ham omelet, potatoes au gratin, crackers, coffee, oatmeal cookie, gum. lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup.

1 April (Fra: .·.·.·. Germany)
2 turkey and cheese sandwiches (on white bread), cola, 2 apple juices, orange, grape danish, granola pudding, granola bar, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup

4 April (Charleston, South Carolina)
Turkey-and-swiss-on-wheat sandwich, breadsticks, potato chips, orange juice, diet soft drink, fruit cup, peanut butter creme-filled wafer, tapioca pudding, rye cheese crackers, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup.

5 April (Zaragoza, Spain)
Ham sandwich (white bread), roast beef sandwich (white bread), cherry juice, orange juice, apple, orange, peanut butter cup, 2 cookies, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup

6 April (Zaragoza, Spain)
Turkey sandwich (white bread), ham and cheese sandwich (white bread), cherry drink, orange drink, orange, apple, peanut butter cup, 2 cookies, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and ketchup.

7 April (Frankfurt, Germany)
microwaveable chile and beef stew dinners, bun,
vanilla pudding, candy coated chocolate candies,
lettuce leaf, tomato slice, pickle wedge, teaspoon
margarine, and one tablespoon each of mustard,
mayonnaise, and ketchup.

9 April (King Faud, Saudi Arabia)
 2 turkey and cheese sandwiches (on sesame seed
hot dog buns), 2 fruit juices, soft drink, cinnamon
granola bar, banana pudding, Danish pastry, lettuce
leaf, tomato slice, pickle wedge, teaspoon marga-
rine, and one tablespoon each of mustard, mayon-
naise, and ketchup.

13 April (Charleston, South Carolina)
 Turkey and cheese sandwich (on white bread),
small salad, 2 breadsticks, bag of potato chips,
cheese, peanut butter sandwich, soft drink, can or-
ange juice, fruit cup, vanilla pudding, large fig bar,
lettuce leaf, tomato slice, pickle wedge, teaspoon
margarine, and one tablespoon each of mustard,
mayonnaise, and ketchup.

15 April (Frankfurt, Germany)
 2 turkey and cheese sandwiches (on white
bread), 2 cans orange juice, soda, banana pudding,
granola bar, lettuce leaf, tomato slice, pickle
wedge, teaspoon margarine, and one tablespoon
each of mustard, mayonnaise, and ketchup.

CHANGES IN FOOD AND ENERGY INTAKE
IN MILITARY AIRCREW

by

C. Helle, K. Kvamsoe, K. Trygg and H.T. Andersen
Institute of Aviation Medicine
PO Box 14
Blindern
N-0313 Oslo
Norway

INTRODUCTION.

Military flying is a demanding profession requiring excellent performance during operations (1). Because the modern western society includes several undesirable lifestyle patterns, dietary counselling has been given increased attention over the past few years in Norway in which country the government has arrived at an official policy of nutritional standards (2).

In order to provide information about the nutritional pattern of military aircrew, the Institute of Aviation Medicine (IAM) carried out a food survey on aircrew at Andøya Air Base in 1986 (3). The present survey is a follow-up study of the 1986 study, using the same squadron and the same method as the previous study.

Our survey has three aims. The first one is to detect any change in aircrew diet over the last six years. Secondly, since the 1986 survey showed that the aircrew took a nutritionally better diet than the average Norwegian population, we wanted to investigate whether this group is still ahead. Finally, we have studied to what extent the irregular working and resting conditions of aircrew influence their meal schedule.

SAMPLE.

The military aircrew at Andøya were selected for the survey, because they work and live under extraordinary conditions. The operational tasks of the squadron include maritime surveillance in the North Atlantic. Such missions of 4-10 hours duration are frequently unscheduled and may be undertaken on short notice during day or night. This irregularity contributes to disrupting a regular meal schedule and encourage taking "in-between" meals.

32 male aircrew participated in our dietary survey as compared to 47 men in the one of 1986. All of the participants lived off base and kept private households. Their average age was 32 in both surveys, and the two groups were also similar with respect to height, weight and Body Mass Index (BMI).

METHOD.

In order to obtain the best basis for comparison, it was decided to use the same method in the 1992 survey as in the previous study. The method employed is a registration of food intake based on household measures and with a booklet of full-scale models provided for

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the subjects. It is a prospective method, which means the intake of food and drink is recorded as it is consumed. Their food intake was measured in four consecutive days; three week-days with either the preceding Sunday or the following Saturday added. The registration period was selected so as not to include National Holidays, vacation periods or temporary duty (TDY).

The participants recorded all their food and drink taken during their chosen four day period. Information of quantities consumed was achieved making the aircrew use the booklet provided in which differer food items are presented as slices of bread, cheese and sausages, pieces of pizza and cakes, sizes of apples and potatoes etc. The amount of butter and bread spreads were indicated with both pictures and figures. The sizes of dinner portions and household measures were illustrated as photographs and drawings respectively. The aircrew were carefully instructed, by ourselves visiting the squadron, how to accomplish the registrations.

A four day registration of food intake with household measures and models is less demanding than the corresponding method with weighing. Obviously, therefore, we have to realize that household measures and portion sizes may vary during the period of observation, both a within-person and an extensive between-person variation (4).

RESULTS.

Table 1 shows the daily intake of energy and main nutrients. The mean value of energy intake was 10 MJ for both groups, the range observed in the previous study of 1986 being greater than in the present. The daily intake of dietary fiber was 18 g per person in both surveys.

Table 1
Daily intake of energy (MJ) and main nutrients (g) in both surveys.

| | 1986 | | 1992 | |
	Mean	St.dev.	Mean	St.dev.
Energy, MJ	9,9	2,7	10,1	2,5
Protein, g	98	27	98	18
Fat, g	91	34	88	25
Carboh., g	263	82	295	94
starch, g	157	51	159	46
sugar, g	43	29	64	46
Fiber, g	18	6	18	6
Alcohol, g	8	17	5	9

Figure 1 shows that the greater part of both groups treated themselves to smaller amounts of energy than the Norwegian reference value, which is 11 MJ for men at their age and level of activity (5).
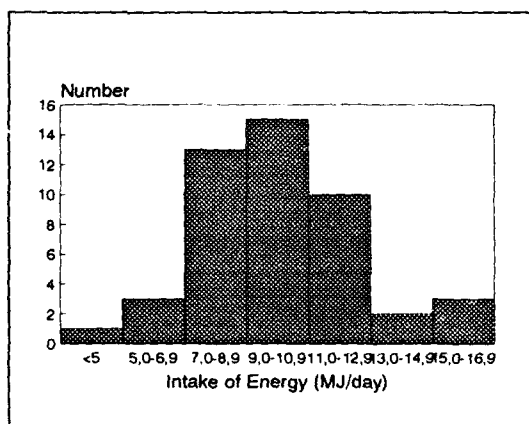
Figure 1a
The distribution of total energy intake in the 1986 survey.
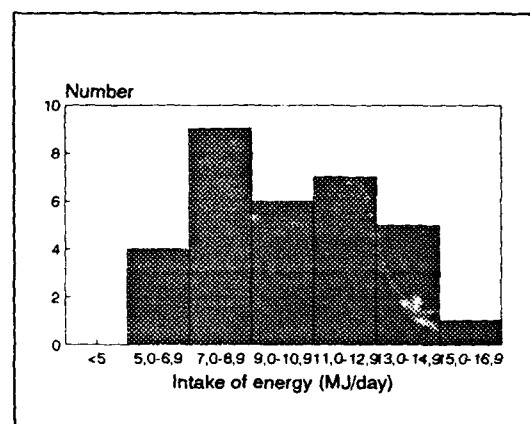
Figure 1b
The distribution of total energy intake in the 1992 survey.

Table 2 shows the percentage distribution of energy. The group of 1986 received 35 per cent of energy from fat while the 1992 group received 33 per cent of their energy from this source. These results exceed the Norwegian nutritional goal for energy derived from fat, which is 30 per cent. The energy per cent from protein is 17 in both surveys.

The amount of energy derived from carbohydrates was 46 and 49 per cent in the 1986 and 1992 survey, respectively. Both surveys showed a lower energy per cent than the recommended level of 55-60. During the last six years, the intake of sugar has increased from 7 to 11 energy per cent.

Table 2
Percentage distribution of energy in both surveys.

Energy source	1986 Mean	Range	1992 Mean	Range	Rec.*
Protei	17	12-28	17	12-25	10-15
Fat	35	19-60	33	23-45	30
Carboh.	46	12-61	49	36-62	55-60
sugar	7		11		-
Alcohol	2	0-21	1	0-9	-

*) Nordic Nutrition Recommendation, 2.ed (5).

Table 3 shows the daily intake of some vitamins and minerals, which is at the same level in both groups.

Table 3

Daily intake of some vitamins and minerals in both groups.

Nutrient	1986 Mean	St.dev.	1992 Mean	St.dev.	Rec.daily allow.*
Vit. A, μg	1107	552	984	706	1000
Vit. D, μg	4,3	3,9	5,8	5,8	5
Tiamin, mg	1,3	0,4	1,3	0,3	1,4
Ribof., mg	2,0	0,6	2,0	0,5	1,6
Niacin, mg	18,9	5,7	17,5	3,8	18
Vit. C, mg	88	45	96	47	60
Ca., mg	1141	394	1173	431	600
Iron, mg	12,5	3,3	12,4	2,4	10
Mg., mg	386	92	381	82	350

*) Nordic Nutrition Recommendations, 2.ed (5).

Table 4 shows the distribution of number of main meals in both surveys. There is a shift towards a greater number of main meals per day, since the number of those having three main meals is increased from 50 to 63 percent during these six years. Likewise, there is only 9 per cent having two main meals in the 1992 group as compared to 24 per cent in the 1986 group. The average number of "in-between" meals per day is reduced from 2,8 in 1986 to 1,9 in 1992.

Table 4

Number of main meals per day in both surveys.

Main meals	1986 Number	%	1992 Number	%
2 main meals	11	24	3	9
3 main meals	24	50	20	63
4 main meals	12	26	9	28

The intake of energy and main nutrients by meals, measured as percentage distribution, is listed in table 5. There is no important change of energy distribution in meals from 1986 to 1992. In both groups breakfast amounts for 20 per cent of the energy and dinner for 37 per cent.

Dinner is the main contributor to fat intake, 41 and 43 per cent of the total amount in 1986 and 1992, respectively. The percentage of sugar derived from "in-between" meals has been increased from 23 per cent in 1986 to 30 per cent in 1992.

Table 5
Intake of energy and main nutrients by meals in both groups.
Percentage distribution.

Nutrient	1986					1992				
	B	L	D	S	IB	B	L	D	S	IB
Energy	22	12	36	22	8	18	20	38	12	12
Protein	21	11	44	20	3	19	19	46	10	5
Fat	20	12	41	23	4	14	22	43	10	10
Carbohyd.	24	21	32	22	10	21	20	32	13	15
starch	25	14	35	23	3	22	21	36	14	8
sugar	19	9	26	23	23	13	16	29	13	30
Fiber	22	11	44	17	6	22	17	39	11	11
Alcohol	-	-	13	31	56	-	-	40	20	40

B = breakfast, L = lunch, D = dinner, S = supper,
IB = "in-betweens".

Regarding consumption of certain foods some significant changes have been observed. The preference for milk among beverages is as obvious in the 1992 study as it was in 1986, almost 50 per cent of the total amount of milk being consumed at breakfast. However, the type of milk consumed has changed remarkably, a significant shift towards the use of milk reduced in fat taking place. The total intake of different fats has become decreased between 1986 and 1992, at the same time the intake of diet margarines has been increased.

The total consumption of fish is decreased in our investigation compared to the 1986 survey while the total intake of meat is held constant. During the six years period the amount of fruit consumed is increased with one-third.

DISCUSSION.

The mean value of energy intake was determined at 10 MJ for both groups as compared to the Norwegian reference value, which is 11 MJ (table 1, figure 1). This lower energy intake is not very different from other groups of Norwegian men whose physical activity at work involves only moderate to easy muscular exercise (6). However, it might reflect an incomplete registration as well. Moreover it is commonly experienced that subjects tend to change their food habits during the registration period.

As shown in table 1, the daily intake of dietary fiber was 18 g per person in both surveys. This is quite low compared to the recommended 30 g per 10 MJ.

The percentage distribution of energy derived from fat was 35 and 33 in the 1986 and 1992 group, respectively (table 2). In 1986 the aircrew food intake contained less fat than the average diet in Norway. From 1986 until 1992 the percentage of energy from fat in the average Norwegian diet has changed from 37 to 35 (7). Apparently, the aircrew are still ahead consuming less fat than the others.

The energy intake from protein, listed in table 2, amounts to 17 per cent, meaning that the aircrew had a relatively high intake of proteins. However, it is not uncommon to compensate some of the energy derived from fat with proteins. A large consumption of skim or low fat milk may be the cause of this relatively high portion of the energy intake.

The amount of energy derived from carbohydrates has increased from 46 to 49 during the six years period (table 2). This increase is not necessarily a positive change, because the increase is due to a greater intake of sugar. Actually, the intake of sugar shows an undesirable increase from 7 to 11 energy per cent. Energy from sugar ought not exceed 10 per cent, the group of 1992 has an intake above this upper limit. These results are in accordance with those obtained from other groups of men whose percentage of energy from fat becomes decreased (8).

The daily intake of vitamins and minerals, listed in table 3, meets on the average, the standards given in the Nordic Nutrition Recommendations (5).

Table 4 shows that a greater number of the participants in the 1992 survey had three main meals per day compared to the 1986 group. The reduced tendency to take "in-between" meals, averaging a fall from 2,8 to 1,9, may have contributed to this increase. It is recommended to have at least three main meals per day, and, considering the irregular diurnal rhythm and meal schedule of the aircrew, this development is considered encouraging.

The intake of energy by meals, listed in table 5, shows that breakfast amounts for only 20 per cent of the energy and dinner for as much as 37 per cent. As much as two-thirds of the amount of energy consumed is derived from food ingested after 3 pm, which makes for an uneven energy distribution during any 24-hour period. Preferably more of the total amount of energy should come from breakfast and lunch the demand on aircrew performance during working hours taking into account.

The percentage of sugar derived from "in-between" meals has, as previously mentioned, increased from 23 to 30 per cent (table 5). This fact may be due to an unfortunate change towards more food rich in sugar in the "in-betweens", and besides, it may explain the increase in total sugar intake from 1986 to 1992 previously mentioned.

The pattern of consumption of certain foods develops positively. Most important is the reduced use of different fats an the increased use of low fat milk. The preference for low fat foods over full fat products appears to be one reason why the previously observed percentage of energy from fat has dropped in the 1992 survey as compared to that of 1986.

CONCLUSION.

The aircrew diet has changed during the period of six years between the two surveys reported in this paper, the most important being a reduced intake of fat and an increased intake of sugar. The total intake of energy being constant.

Although too much energy is derived from fat, the diet is still better than the average in Norway. Apparently, the aircrew meal schedule is not negatively influenced by the extraordinary working and living conditions at Andøya Air Base.

The intake of vitamins and minerals meet the recommended standards, and the energy consumed is largely derived from food sources commonly used in a Norwegian household.

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TRIAL OF EMERGENCY RATIO OF THE SPANISH AIR FORCE

Antonio Mendez Martin
Servicio de Nefrología
José Ignacio Peralba Vaño
Servicio de Medicina Interna
Hospital del Aire
Madrid 28027
Spain

INTRODUCTION

Nutrition is a wide and extensive concept. A flood of information is available on military and emergency ratios. However to our knowledge except for a few countries not mach research on military nutrition was done. NATO recognized the need for more information in this field during this last decade. Its defense research group created a study group to evaluate the nutritional aspects of military feeding under panel 8 on the defense applications of human and biomedical sciences. This report provided a greed nutritional criteria for operational rations besides other very interesting recommendations for Garrison feeding and alimentation of wounded personnel. Also nutritional guidance to sustain physical performance during prolonged work, and different environments were analyzed. It recollected and up to date description of composition and purpose of the rations in NATO countries and described the tailed methodologies for nutritional evaluation of different rations and feedings besides other guidelines on nutrition, obesity, risk factors for CAD, education programs and dietary goals for military populations.

In these days of cuts in military expenditures and the need of cost effectiveness the concept of adequate nutrition needs to be highlighted again. The ultimate performance of the human element, air crews, pilots and rest of military personnel is directly linked to this issue. In fact it is probably as important as the rest of the soft and hardware employed in any mission. It has always been known in history how a good nourished and healthy army or individuals can alter the balance or results in any war, battle or task.

Correct nutrition even in our food-rich environment is also and important issue by itself. But such important aspects as improvement of nutritional status, prevention of disease and promotion of health are beyond the scope of this presentation.

Never the less this peace time easy availability of nutrients makes us forget the fact that in war or especial missions these are often overlooked. Military personnel, specially soldiers in battle or on maneuvers in inhospitable areas, must always be ready and able to use their entire energy in defending their country, realizing specific military objectives and in ensuring their own survival. Normally territorial and mobile logistic devices provide them the security and physical and psychological support necessary to maintain this readiness which is even more crucial in case of pilots and air-crews. However, there are times when a soldier or unit are

isolated for and indefinite period. In Instances such as these when the soldier must meet his military obligations without logistical support, he should be confident in the adequacy of field rations, which may be his sole source of nutrition in extreme situations. These could include, natural disasters, sudden emergency deployments and rescues in remote areas. Scenarios like those listed before expose troops to extreme conditions and stress demanding a diet that will guarantee retention of the physical stamina and mental concentration and reflexes necessary both to survive potentially harsh conditions and to successfully operate often complex weaponry systems.

In the Spanish Air Force the Emergency Ration from Pfrimmer Labs. was implemented to provide an adequate product for supplying nutrition in extreme conditions fulfilling, the need that so often arises during times of emergency or during periods of logistical inadequacies. For this reason it is an irreplaceable component of standard military issue in the Spanish, Air Force. But no trial or study had so far being done to test this E.R. in real life conditions. Finally we must realized the following issues:

1. Today's military operations and relief efforts are by nature most dependent on pilots and aircrews who are often working two to three times the normal duty hours in frequently unfamiliar or even hostile environment, without access to the usual sources of nutrition and often with limitations of volume and weight.

2. This operations are nowadays conducted most of the time by multinational forces whose operations often extend to the sharing of supplies.

3. Based on the previous fact we believe that there is clearly a need of standardization of equipment and supplies in order to improve operation readiness and performance.

To take the necessary steps towards a standardized cost/efficient and physiologically correct emergency ratio would be an important goal. With today knowledge and the experience standardized NATO survival and emergency rations would probably result more economic and operational. Combat rations would certainly need a slight different approach then cultural taste and food acceptance become more relevant.

With this study where we tested this ratio in real life , we have tried to open a line of research and at the same time present this issue for discussion.

MATERIAL AND METHOD.

We evaluated 10 healthy volunteers all of them, medical students in which anthropometric, metabolic and psychological test were performed before, midthrough and at the end of the trial being subjected to exclusive nourishment with the S.A.F. E.R. for one week. Five were males with average age 21.2 years, weigh 64.68 Kg and height of 171.6 cm; five females average age of 20.5 years, weigh 56.82 and height of 167.7 cm.
Exclusion criteria were based on:
1. Existence of any past, recent or current pathological condition.

2. Use of drugs or medications.

3. Following in the previous months any vegetarian or hypocaloric diet.

4. Smoking more than one pack per day or alcohol consumption.

5. At the time engaged in any regular competitive sport activities or professional sports.

6. Body weight or any other of the evaluated parameters presenting larger than 15% deviation from 50th percentile on average physiological normal figures.

Duration was 7 natural days and the volunteers were only allowed to be fed by the ER exclusively 1000 Kcal/day/subject distributed in three dosages.

The were allowed to drink only water or light infusions (less than 2 liters). Their activity level was their usual way of life (which includes 4 hours of lecture per day, 2 hours of clinical practice, 2 hours study, 1 hour moderate exercise, 5 hours of leisure time and 8 hours rest). The trial was done in Madrid 660 mts altitude in February with average temperature of 15°C to 20°C.

Parameters where evaluated on T0 (08.30 am, day 0), T1 (08,30 am, day 4th) and T2 (08,30 am, day 8th).

Parameters studied, were chosen based on previous works (2,3,4,11,14,15,17,24,26) and are shown in Table I.

Autotest method are shown in Table II.

Table III described the composition of the E.R.

RESULTS

Results of the different parameters studied are shown in Tables IV and V.

Autotest results are shown in Table VI.

Statistical Analysis is significant with p<0.05
All values were expressed as mean ± SE. Student t test and the X^2 test for association were used to compare groups and initial values (T0) with rest of data obtained in T1 and at the end of the trial T2.

P value less than 0.5 were considered significant.

DISCUSSION

The SAF ER agrees with modern nutational concepts (rules of Food and Nutritional Board of US Committee on Nutrition and human need, National Academy of Sciences (1977), Deutsche Gesselschaft fur Ernahrung (DGE, Germany), the recommendations of FAO-WHO 1974 () and Committee of Dietary Allowances 1980 (National Research Council), NATO STANAG 2937; AC/243 panel 8/RSG 8, D/9 (1989) and other current publications and studies (5,6,7,8,9,18,23).
Because the SAF did not have the resources to develop a new SAF selfmade ER, the decision was made to substitute the previous old nutritional imbalanced ER for a new one which fulfilled the current nutational and logistic requirements (ER from Pfrimmer Labs).
This ER is easily digestible, palatable and produces a lasting satiation effect as a result of the favorable nutritional balance. Easily absorbed carbohydrates and fats, high in energetic values, preventing quick tiring and morning slump.
It is rapidly absorbed and its protein portion is constituted by high quality and highly concentrated mixture of animal proteins of high biological values.
It is readily available, a ready- to- eat, in to palatable flavors. Requires only limited space for storage, minimizing logistical problems.
Because it is compact (low weight - 245 g) and small it is easily transported in the military gear or aircrew equipment.
It has and exceptional long shelf-life remaining stable under extreme climatic conditions (remain stable for at lest 4 years under tropical conditions).
In this trial we have shown that in a setting of average daily activity it can sustain the operation capability for at least seven days

in the event that regular food suplies are disrupted.

Water is assumed to be available to an amount of 1.5-2 liters.

This ER fulfills the current recommendation of STANAG 2937 being small in volume with and energy value of 3.950 KJoules=KCal., provided in portions of 14% from proteins, 26% from fats and 60% from carbohydrates.

It suitable for comsuption without cooking, eating or the addition of water.

It has included instant beverage powder.

We agree with the experimental evidence that more than 450 carbohydrates per day are required to facilitate glycogen resynthesis, then once the glycogen stores are depleated subsequent exercise performance is impaired (12,13). However although most studies (16,19) found fat rich diets inadequate some (22) leave a door open, showing that in a certain setting (after periods of adaptation in endurance trained individuals), fat rich ketogenic diet, could be useful without impairing performance and with the advantage of reduce weight (up to 50%) to be carried or stored.

The ER is calculated to sustained operation for a brief period of time (at least 24 h). But deviation from accepted nutritional guidelines in certain operational scenarios as those listed before or others (suply line breaks covered operations, long range patrols on missions without resuply or special units that restrict their nutrition to lower the loads to be carried), may occur quite often.

Because of weight, volume or availability these deviations will then be a must.

Certain authors (19) stated that caloric restrictions causing gradual weight loss up to about 10%, will not cause drastic performance deficits.

The results in our trial showed no major nutritional or metabolic impairment. Only constipation was significant but never became a major problem and it is by itself a frequent and not too specific findings (27).

However the number of probands was small. Always young and with correct nutritional status (8,1,17). Under stable external factors, no climatic variations and mild temperature (10), constant mild altitude, regular work/rest cycles and did not undergo any strenuous physical activity; therefore caloric expenditure was only moderate compared to certain military scenarios (field trials for days, long range patrols etc.). Also endurance and strength were not studied in depth.

Because of this differences our findings cannot be fully extrapolated to intense combat scenarios. The trial does assess the nutritional and metabolic value of this ER. No trial has been made prior to the present one, in the Spanish Military with ER in real life conditions.

The results of this study validates its use in the military environment.

This choice of ER and this trial reflects the interest of the SAF Health Service to improve the nutritional and operational standards of SAF personnel.

Further studies are planned to validate ER in more extreme conditions.

CONCLUSIONS

1. The ER does not produce any significant changes (anthropometric, biochemical and immunological) in all the probands evaluated during seven days when the sole nutriment was the SAF ER.

2. No significant loss of weight and subcutaneous fat.

3. ER does not affect working capacity (physical and intellectual) or impact on usual daily activity.

4. ER does not modify the quality of life (usual lifestyle).

5. ER produced no metabolic or

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1 - PARAMETERS TO EVALUATE

1. GENERAL

AGE   T0
BLOOD PRESSURE   T0-T1-T2
PULSE RATE   T0-T1-T2
DAILY DIURESIS   T0-T1-T2
(M.V.=Vol./mn.)

2.ANTHROPOMETRIC

HEIGH   T0
BODY WEIGHT   T0-T2
TRICEPC SKIN FOLD   T0-T2
(Mc.Graw calibre)
SUBSACPULAR SKIN FOLD T0-T2
ARM CIRCUNFERENCE   T0-T2
ARM MUSC. CIRC   T0-T2

3.BIOCHEMICAL-NUTRITIONAL (IN SERUM)

SEROALBUMIN (ELECTROFORESIS) T0-T2
PREALBUMIN (REA)   T0-T2
TRANSFERRIN (BIOCHEM.AMES-SERAPAC) T0-T2

4. BIOCHEMICAL-METABOLIC (IN SERUM)

ELECTROLYTES (Na, K, Cl, COBH-) T0-T2
UREA (BUN)   T0-T2
CREATININE   T0-T2
(All these det. by Beckmann Phot.)
OSMOLARITY (Krauer Osmometer) T0-T2

5.BIOCHEMICAL-METABOLIC (IN URINE)

DENSITY
pH OSMOLARTY
Na/K   T0-T1-T2
CREATININE
UREA

6.MIXED. METABOLIC-NUTRITIONAL

CREATININE/HEIGHT INDEX   T0-T2
CREATININE CLEARANCE   T0-T2
OSMOLAR CLEARANCE   T0-T2

7.INMUNOLOGYCAL

TOAL COUNT OF LYNPHOCYTES IN PERIPHERAL BLOOD T0-T2

3 - EMERGENCY RATION COMPOSITION:

1) NUTRITIONAL CONSTITUENS:

- 10 chewable bars (Orange and chocolate flavours). 21 g. each = 210 g. total)
Each individually wrapped in aluminun foil.
- Total caloric value = 3950 Kj = 1000 Kcal.
- Size: 136 x 90 x 23 mm. ; Volumen: 250 ml.
- Its ration (210 g.) contains approximately:

  * 14% energy: proteins = 32 g. mixed animal. ovoalbumin (90%) and vegetal
  protein (10%). -
  * 26% energy: fat = 27 g. medium chain tryglycerides (69%) and long chan
  tryglycerides (31%).
  * 60% energy carbohidrates = 151 g. glucosa (61%) oligo and polysacarides
  (39%).
  * Balance minerals:

  Na = 24 mmol   k = 17,5 mmol
  Ca = 2,4 mmol   P = 8,0 mmol
  Mg = .3,6 mmol   Cl = 18.2 mmol
  Fe = 4,6 mmol

  * Crude fiber = 0,9 g.

2) Other constituens:

- Instal coffee = 1 bag
- Non caloric sweetener = 2 tablets
- Chewing gum without sugar = 5 bags

Dentire e.r. is wrapped in special aluminun foil bag wich can be itself used asa a
container for drinking water, etc. Complete instructions and specifications are
printed on the bag and include the expiration date.

Total weight: 245 g.

2 - AUTOTEST METHOD

CONCEPT	GROUP
1.-GENERAL CONDITIONS (WELL-BEING)	1
2.-CONCENTRATION CAPACITY	1
(Developement of intelectual activities)	
3.-CAPACITY TO CARRY ON WITH USUAL LIFE STYLE	1
4.-APPETITE	2
5.-THURST	2
6.-PHYSICAL ASTHENIA	2
7.-RESTING TYME (BED/SITTING)	2
(<10->8 HOURS)	2
8.-SONNOLENCE	
9.-INSOMNIA	2
10.-CONSTIPATION (<1 B.M. PER DAY)	2
11.-GASTROINTESTINAL PROBLEMS	2
12.-MOUTH BAD TASTE	3;

DURATION PERIOD: T0-T2
VARIATION POSSIBILITY 0 TO 48 PER PROBAND

EVALUATION ALEATORY SYSTEM: T.0 vs. T2

0=NORMALITY/USUAL SITUATION.LACK OF CHANGE
+1=SUPERIOR LEVEL COMPARED TO NORMALITY.
+2=MAXIMUN CHANGE COMPARED TO NORMALITY
-1=INFERIOR TO NORMALITY.

4 - RESULTS

1.-GENERAL PARAMETERS:
NO SIGNIFICANT STATISTIC (S.S.) VARIATIONS IN:
  BLOOD PRESSURE
  PULSE RATE
  DAILY DIURESIS(M.V.=VOL. MIN.)CORRECTED TO AMMOUNT OF LIQUIDS CONSUMED.

2.ANTROPOMETRIC PARAMETERS:
WEIGHT NO S.S. VARIATION IN FEMALE PROBANDS. DIMINUTION (P<0.5) IN MALE PROBANDS.
TRICIPITAL FOLD: NO S.S. VARIATION IN FEMALE PROBANDS. DIMINUTION (P<0.5) IN MALE
PROBANDS.
SUBESCAPULAR FOLD: NO s.s. VARIATION.
ARM CIRCUNFERENCE: NO S.S. VARIATION IN FEMALE PROBANDS. DIMINUTION (P<0.5) IN MALE
PROBANDS.
ARM MUSC. CIRC.: NO S.S. VARIATION.
IN THE WHOLE GROUP OF PROBANDS: NO S.S. VARIATIONS

3.-BICHEMICAL-NUTRITIONAL PARAMETERS.
SERUMALBUMIN:NO S.S. VARIATIONS.
PREALBUMIN: NO S.S. VARIATIONS IN MALE PROBANDS. DIMINUTION (P<0.5) IN FEMALE
PROBANDS.
TRANSFERRIN: NO S.S. VARIATION IN FEMALE PROB. DIMINUTION (P<0.5) IN MALE PROB.

IN THE WHOLE GROUP OF PROB.: NO S.S. VARIATION.

5 – RESULTS

6 – AUTOTEST RESULTS

4.-BIOCHEMICAL-METABOLIC PARAMETERS (IN SERUM)

NO S. S. CHENGES IN ANY OF THEM

5.-BOCHEMICAL-METABOLIC PARAMETERS (IN URINE)
NO S. S. VARIATION IN: pH; M. V. AND DENSITY
DIMINUTION (p<0.5) IN:
- OSMOLARITY IN THE MALE GROUP
- Na/K RATIO IN BOTH GROUPS
- UREA IN BOTH GROUPS

6. MIXED PARAMETERS METABOLIC-NUTRITIONAL:
NO S.S. CHANGES IN ANY OF THEM

7. IMMUNOLOGYCAL PARAMETERS:
NO S.S. CHANGES IN TOTAL LYMPHOCYTE COUNT; SLIGHT TENEDENCY TO INCREASE.

-28 VARIATIONS T0 vs. T2 EQUAL TO 5.83% OF ALL THE POSIBILITIES (480)

-12 VARIATIONS IN MALE PROBANDS (2.4/PERSON) AND 16 IN FEMALE PROBANDS (3.2/PERSON)

-MODIFICATION-IMPROVEMENT/DETERIORA
TION-RATIO 1/1.8 GLOBAL,FEMALES 1/1.67,MALES 1/1.9

-VARIATION IN CONCEPT GROUPS:
GROUP1(3CONCEPTS) 2VARIATIONS
GROUP2(8CONCEPTS) 14 '
GROUP3(8CONCEPTS) 12 '

-CONEPT DEMONSTRATING MORE VARIATIONS THAN OTHERS N° 10 (6VARIATIONS)=CONSTIPATION
OR SLOW-DOWN OF INTESTINAL RYTHM

EVALUATION OF ORGANOLEPTIC ACCEPTANCE OF E.R.

GRADUATION FRON 1 TO 5 POINTS PER PROBAND IN TYME 2

AVERAGE IN 10 PROBANDS =3
GROUP OF MALE PROBANDS =3.2
GROUP OF FEMALE PROBANDS =2.8

IDIOPATIC REACTIVE HYPOGLYCEMIA IN A POPULATION OF HEALTHY TRAINEES OF AN ITALIAN AIR FORCE MILITARY SCHOOL

Stefano Farrace; Luca Urbani; Lorenzo Sakara; Claudio De Angelis

D.A.S.R.S., Reparto Medicina, Aeroporto Pratica di Mare
00040 Pomezia, Roma, Italy

Abstract

Idiopathic Reactive Hypoglycemia (IRH) was investigated among a population of young trainees of an Italian Air Force military school. One hundred and twenty male healthy subjects underwent a 300 min Oral Glucose Tolerance Test (OGTT) after an overnight fasting. Nine out of 120 subjects (group A: 7.5%) showed a glycemic nadir below 50 mg/dl. Moreover, in group A 8 out of 9 subjects reported symptoms referable to clinical hypoglycemia during the glycemic nadir. Furthermore, a lack in glucagon response to hypoglycemia was observed in group A. Data are suggestive for the presence of Idiopathic Reactive Hypoglycemia in group A subjects. Data suggest that IRH may be considered relevant as a possible reason of in-flight accident due to human factor.

Introduction

Idiopathic reactive hypoglycemia (IRH) is, by definition (1), a form of hypoglycemia that typically occurs as a consequence of carbohydrate ingestion, in subjects without any other alteration of glucose homeostasis or other endocrine diseases, or previous gastrointestinal surgery. With regard to the etiology of IRH in many cases a delayed insulin secretion has been observed (4), while Luyckx (5), and more recently Tamburrano (7) have suggested that peripheral insulin sensitivity might play a role in this homeostatic disorder. The frequency of IRH has been reported to be up to 7 % in the general population (2). Considering this relatively high frequency reported in an otherwise healthy population and given the deleterious effect of impaired blood glucose concentration on central nevous system (CNS), it may be important to investigate the frequency and magnitude of IRH among subjects selected to performe high performance duties. Thus it has been the aim of this study : to evaluate the diffusion of IRH in a population of young healthy trainees of an Italian Air Force military school.

Methods

One hundred and twenty healthy males (age 19 ± 2 yr - BMI : 22.3 ± 2.2) selected among over 2,000 trainees underwent a 5 hours oral glucose tolerance test (OGTT) according to (2), (75 g per os - Curvosio 50% solution, 50 ml, Sclavo, Italy), after an overnight fasting, starting at 8 a.m. All subjects observed a diet with 250 g of carbohydrates/day during the last 3 days before the study. Each subject had neither history of diabetes nor other metabolic or endocrine diseases and a clinical examination resulted negative in all of them.

Protocol : A 16G angiocatheter was inserted in each subject in an antecubital vein and blood glucose baseline value was twice previously obtained. Afterwards blood samples for insulin and glucose determination were collected every 30 min for the first 3 hours and every 15 min for the last 2 hours. Glucagone and cortisol assays were also performed but only in subjects whose glycemic nadirs were below 50 mg/dl. Subjects remained seated throughout the study and they were asked to answer to a questionnaire about the symptoms listed in table 1.

Analytical procedures : Blood glucose concentration was determined during the OGTT by the glucose oxidase method (Glucose analyzer II, Beckman, Palo Alto, CA), while blood for hormonal determination was collected in EDTA and 500 U/ml aprotinine tubes. Blood was centrifuged (15 min at 3000 rpm) and plasma was stored at - 20°C until assayed. Insulin, glucagon and cortisol were determined on plasma run in duplicate by double antibody RIA technique (commercially available kit Ares Serono, Italy).

Statistic: Data are presented as mean ± SEM, significant differences (p<0.05) were calculated adopting Student's t test for unpaired sample when appropriate.

Results

Nine out of 120 subjects (7.5% - group A) showed a glycemic nadir < 50 mg/dl mainly between the 180th and the 225th min of the OGTT. Blood glucose mean profile in group A (fig.1) showed values always significantly lower compared with the other subjects with the exception of time 90th min. Eight subjects of group A complained for symptoms referable to hypoglycemia as reported in table 1 during the glycemic nadir. Mean insulin profile in group A (fig. 2) was characterized by higher values at almost each time of the OGTT, even though at time 0, 30th and 150th min only they were significantly different (p<0.05). Mean nadir plasma glucagon concentration (fig.3) was unexpectedly significantly lower in group A as compared to the mean baseline value of the same group (nadir : 57.59 ±3.1 pg/ml vs baseline : 65.43 ± 2.8; p<0.05), while cortisol although slightly increased at the nadir did not show any significant difference (nadir : 58.4 ± 3.4 ng/ml vs baseline : 56.9 ± 2.3 ng/ml; p=NS).

Fig. 2: Plasma insulin mean profiles during the OGTT in group A (dashed bars) vs controls (white bars) (*=p<0.05)
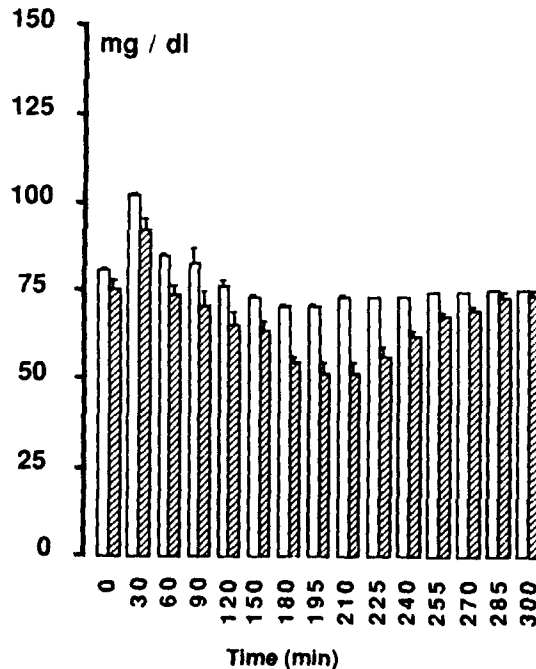

Fig. 1 : Plasma glucose mean profiles during the OGTT in group A (dashed bars) vs controls (white bars).(Differences between group A and controls are always significant at each time with the exception of time 90th min; p<0.05).
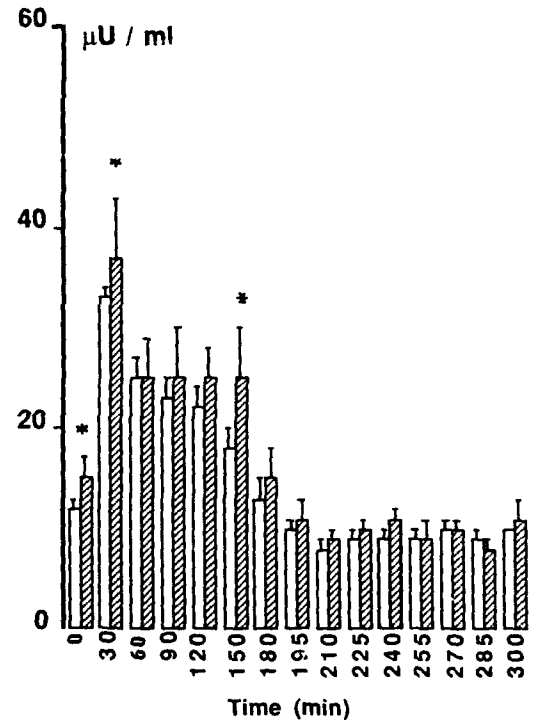
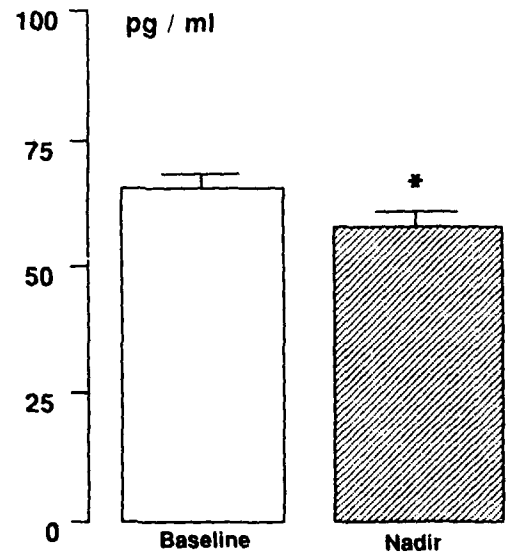

Fig. 3 : Mean nadir and baseline glucagon plasma levels in group A (* : p < 0.05 vs baseline).

Tab. 1
Distribution and frequency of symptoms in group A during a glycemic nadir with blood glucose concentration < 50 mg/dl.

Symptoms	Number of subjects
Hunger	7
Tremor	4
Sweating	3
Palpitations	2
Anxiety	2
Dizziness	1
Headache	1
Weakness	1
Blurred vision	1
Confusion	1

Discussion

Our data showed a 7.5% of subjects with a well defined hypoglycemic reaction after carbohydrates ingestion, which is highly suggestive for IRH. This frequency in a healthy population is consistent with others previously reported (2).

The pathophysiologic mechanism wich may lead to the onset of IRH still needs to be further investigated , even though a lack in glucagon response at the glycemic nadir in group A is consistent with an impairment of counterregulatory function which might have been enhanced by the higher plasma insulin concentrations observed in the same group. However, these findings are consistent with what has already been reported by other Authors (4-7).Focusing our attention on the specific aim of this study, De Feo et al. (3) reported that hypoglycemia may be a late indicator of an advanced neuroglycopenia, since they observed an early increase of P-300's wave latency after a mild decrease in blood glucose concentration induced by insulin infusion. As far as P-300 evoked potential is a physiologic correlate of brain function (since it is related to cognitive processing of stimulus information), it means that alterations in the transmission of the same evoked potential may represent an impairment in central nervous system function, which has to be prevented and especially in personnel employed for high performance duties. Thus we may conclude that IRH, also taking into account the more precocious disturbances brought by its possible neuroglycopenic implications, must be carefully prevented in pilots; moreover the relatively high frequency found in our population may suggest that IRH might have been underestimated as potential reason of in-flight accident due to human factor, and

since the main triggering factor of IRH remains carbohydrate ingestion, it is advisable to limit carbohydrate intake before flying and to avoid those characterized by fast absorption.

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LES DYSLIPIDEMIES DANS LE PERSONNEL NAVIGANT MILITAIRE FRANCAIS

A. SEIGNEURIC
J. P. BURLATON
J. DEROCHE
R. RICHARD
A. BOUSSIF

Service de Médecine Aéronautique
Hopital d' Instruction des Armées D. Larrey
1 rue de l'Indépendance Américaine
78000 Versailles -FRANCE

RESUME

Les troubles du métabolisme lipidique dans le personnel navigant français,ont été évalués à partir d'une population hospitalisée pour expertise aéronautique entre 1980 et 1989. Une anomalie: - hypertriglycéridémie pure (hyper TGD) -dyslipidémie mixte -hypercholesterolémie (hyper CT) isolée, a été reconnue dans 52,3% des cas (483/923). Une hyper CT avec un risque majoré a été affirmée dans 34,8% des cas (294/923). C'est dans le groupe des controleurs que cette anomalie est la plus fréquente avec 40% des sujets atteints (50/120) alors que 30% environ des sujets sont atteints dans les divers groupes de pilotes ainsi que chez les mécaniciens et navigateurs.
Le suivi effectué chez 177 navigants sur une période moyenne de 2 ans et demi, a montré l'existence d'une atteinte cardiovasculaire chez 12% des sujets. La prise en charge thérapeutique (régime +/- médicament) a été effective dans 45% des cas. La baisse des chiffres du cholesterol, des triglycérides et d'un facteur multifactoriel de risque s'établit aux environs de 10%.

PRESENTATION DE L' ETUDE

Les troubles du métabolisme des lipides constituent un des plus importants facteurs du risque vasculaire et sont l'objet d'une attention toute particulière lors de la surveillance du personnel navigant. Un dosage du cholesterol sanguin et des triglycérides est effectué à la visite d' admission et répété ensuite au cours de la carrière du pilote à un rythme variable selon l'emploi de l' intéressé.
Dans ce travail réalisé auprés du personnel navigant (PN) militaire français, nous avons eu pour but un recensement des dyslipidémies observées, une caractérisation de ces anomalies parmi les différentes catégories de PN puis une approche de leur suivi : mode de traitement, modification des valeurs des dosages, influence sur l'aptitude.

Caractéristiques générales.

Il s'agit d'une étude rétrospective ayant porté sur l'ensemble d' une population de personnels navigants hospitalisés dans le service de Medecine Aéronautique de Versailles. Ils présentaient des pathologies trés variées nécessitant des explorations complexes en vue de déterminer la possibilité d'être maintenus aptes dans leurs fonctions.
Durée: La période considérée s'étend sur 10 ans, entre le 1er janvier 1980 et le 31 décembre 1989.
Dosages effectués: Tous ces membres du PN ont bénéficié, quelque soit le motif de leur hospitalisation, d'un dosage du cholestérol total sanguin et des triglycérides ainsi qu'une évaluation des principaux facteurs de risque vasculaire: consommation de tabac, mesures de la tension artérielle Ces données ont été recontrolées à chacune des visites du suivi. Le dosage des fractions du cholesterol n'a été réalisée que dans une période récente et ne figurera donc pas dans cette étude.
Valeurs seuils: Les limites pathologiques sont celles définies par la conférence de consensus européen sur les dyslipidémies de Naples en 1986 dont les valeurs sont précisées dans le tableau 1 en grammes/litre,unité qui est apparue mieux adaptée que les millimoles/litre. Les chiffres sont trés voisins de ceux du National Institute for Health (2)

	seuil des hyper C T	seuil des hyper C T à risque majoré	seuil des hyper T G D
AVANT 20 ans	> 2g/l	> 2,2 g/l	
de 20 à 39 ans	> 2,2 g/l	> 2,4 g/l	> 2 g/l
de 40 à 60 ans	> 2,4 g/l	> 2,6 g/l	

Tableau 1

L'inclusion dans l'étude a bien pris en compte les variations des niveaux limites de l'hyper CT en fonction de l'age en séparant 3 tranches de population qui ont ensuite été rassemblées pour une présentation globale des résultats. Un niveau de risque majoré dans le groupe des hyper CT a permis d'isoler cette population au sein de la population globale des dyslipidémies

Etude globale du risque. L'évaluation du rôle de l'ensemble des autres facteurs de risque s'est faite à partir d' un coefficient multifactoriel "C" qui permet de prendre en compte, outre le niveau du cholesterol, la pression artérielle systolique et la consommation de cigarettes ainsi que l' état diabétique.

C = 0,8 x cholesterol total (en g/l)

+ 0,145 x Pression artérielle systolique (en cm Hg)

+ 0,031 x nombre de cigarettes /jour

(+ 0,86 en cas de diabète)

Ce coefficient résulte d'une étude prospective parisienne sur les facteurs de risque des cardiopathies ischémiques (1). Le risque global est considéré comme significativement élevé à partir de 4,5 et surtout de 5.

Une partie de la population des porteurs d'une hyper CT à risque majoré a pu être suivie dans le service et son évolution sera rapportée.

Echantillon initial

La population globale initiale est de 923 personnes. Elle représente assez fidèlement l'ensemble des PN de l'Armée de l'Air et de l'Aviation Légère de l'Armée de Terre. Par contre les personnels de la Marine ne sont pas représentés.

Le groupe des pilotes de chasse est le plus nombreux avec 213 personnes, précédant de peu celui des pilotes d'hélicoptères au nombre de 200. Puis on trouve 149 pilotes de transport. Les mécaniciens navigants constituent avec les navigateurs un groupe de 144 personnes. Les controleurs ont été assimilés aux personnels réellement navigant, ils sont 120 autotal.Les élèves pilotes constituent un groupe non négligeable de 97.

Seules, 3 de ces personnes sont du sexe féminin.

Séparation des diverses populations

Le groupe des dyslipidémies totales présente les critères des valeurs supérieures à la normale pour le cholesterol total et/ou les triglycérides définis dans le tableau 1. Il correspond à 483 personnes soit 52,3 % de l' échantillon. Une élévation isolée des triglycérides a été retenue 11 fois seulement. Une dyslipidémie de type mixte se retrouvait 90 fois et une hyper CT 382 fois.

Parmi l'ensemble des 472 hyper CT, pures ou associées à une hyper TGD, 294 (soit 62,3%) ont les critères d' un risque élevé.

L'étude du suivi sera faite sur 177 personnes de ce dernier sous-groupe.

RESULTATS
Groupe des dyslipidémies totales (tableau 2)

Cette présentation de l'ensemble des dyslipidémies montre un age moyen de 36 ans, un niveau moyen du taux de cholesterol à 2,62 grammes par litre et un facteur "C" moyen à 4,4. Vingt pour cent de cette

population est constituée par des hyperlipidémies mixtes qui ont les niveaux moyens les plus élevés aussi bien pour le cholestérol total, que les triglycérides et le facteur "C". Remarquons que l'age de cette population est de 39 ans, nettement plus élevé que celui des hyper CT pures qui est de 35 ans seulement.

	n	age	C T.	T G D	indice "C"
HYPER T G D	11	40	1,98	2,70	4,2
HYPERLIPIDEMIES MIXTES	90	39	2,84	2,93	4,7
HYPER C T	382	35	2,58	1,15	4,3
TOTAL	483	36	2,62	1,52	4,4

Tableau 2

Groupes des hypercholesterolémies

Nous avons établi ici une comparaison dans chaque groupe professionnel du pourcentage de sujets d'une part porteurs d'une élévation du taux de cholestérol quelqu' en soit le niveau et d'autre part ceux situés au-dessus du niveau à risque.(Figure 1)

Le groupe des élèves est évidemment le plus faiblement atteint avec 24,7% du total de cette population présentant des chiffres anormaux pour le cholesterol et 9,3% de sujets à risque majoré.

Celui des controleurs est au contraire le plus fortement touché avec plus de 40% de sujets présentant des valeurs supérieures au seuil à risque.

Les 4 autres groupes se situent à des niveaux pratiquement identiques, très voisins de 30%

Groupe des hypercholesterolémies avec suivi
Durée du suivi

Le suivi moyen a été de 2 ans et demi avec un maximum de 7 ans. Pour 20% de la population. ce suivi a dépassé 3 ans.

Caractéristiques de la population

L'age moyen est de 37 ans.

Les pilotes d'hélicoptères sont les plus nombreux n = 48; soit 27% de l'ensemble.

ensuite les pilotes de chasse n = 36, les controleurs n = 35, le groupe mécaniciens-navigateurs n = 33, les pilotes de transport n = 23.Les élèves sont réduits à 2 personnes.

Nature des anomalies

Dans 52 cas, il s'agit d' une dyslipidémie mixte et dans les 125 cas restants d'une forme pure d' hyper CT.

Le niveau moyen du cholesterol est de 2,83 g/l avec un maximum à 4,9 g/l

Celui des triglycérides est à 1,73 g/l avec un maximum à 8,75.

La valeur moyenne du facteur "C" est à 4,6.

Comparaison des différentes catégories (Figure 2)
Elle montre des valeurs du cholesterol très voisines
pour les pilotes de chasse, les controleurs, le groupe
mécaniciens-navigateurs, les pilotes de transport et
ceux d'hélicoptères puisqu'elles se situent entre 2,80
et 2,86 g/l. Seul, le groupe des 2 élèves se situe à un
niveau inférieur de 2,67 g/l.
Les triglycérides ont une répartition plus large entre
0,83 et 2,13 g/l
Le facteur "C" est relativement homogène pour
l'ensemble des catégories, il se situe en moyenne à
4,5; c'est à dire au seuil de la valeur considérée
comme représentative d'un risque. Cet indice est
majoré uniquement pour les controleurs à 4,8.

Retentissement cardio-vasculaire
A la fin du suivi, on pouvait dénombrer 21
évènements cardiovasculaires soit 12% de la
population. Neuf de ces évènements, 5 atteintes
coronariennes et 4 atteintes artérielles périphériques
avaient été constatés au moment de l'entrée dans
l'étude; les 12 autres, représentant 6,8% du total, ont
éte constatés au cours du suivi.

Prise en charge thérapeutique,
On doit remarquer tout d'abord qu'elle était déja
instaurée à l'entrée dans l' étude dans 40% des cas,
essentiellement par le biais d'un régime puisqu'il était
prescrit dans 34% des cas. Ceci traduit le fait que au
moment de l'entrée dans l'étude un certain nombre de
pilotes étaient déjà suivis soit dans le service, soit par
leur médecin d'unité pour cette anomalie métabolique.
Au cours du suivi, diverses modifications du
traitement ont pu être opérées: passage du régime seul
à une association avec un médicament hypolipémiant,
changement de médicament, parfois même arrêt du
médicament.
En définitive, prés de 45% des sujets étaient
régulièrement traités à la dernière hospitalisation.
Le traitement médicamenteux était constitué presque
exclusivement par des produits de la famille des
fibrates, dont la tolérance a toujours été excellente

Efficacité de la prise en charge
L' efficacité de ce suivi et de cette thérapeutique a été
évaluée en considérant l' évolution des chiffres du
cholesterol, des triglycérides et du facteur "C"entre le
moment de l'entrée dans l' étude et le dernier controle.
La cholesterolémie moyenne passe de 2,82 g/l à 2,51
g/l soit une baisse de -11%.
Les triglycérides passent de 1,75 g/l à 1,55 g/l, soit
une baisse également de -11%.
Quant à l' indice multifactoriel "C", il évolue de 4,6
à4,2, la réduction observée est de 8,7 %.

Influence sur la décision d'aptitude
La population étudiée se présentait avec des
pathologies trés variées dont un grand nombre n' avait

aucune relation avec une anomalie lipidique. On a
donc évalué la place que pouvait occuper une telle
anomalie, de façon directe ou indirecte, dans la prise
de décision concernant l'aptitude aéronautique.Cette
place n'est pas négligeable puisque elle correspond à
un tiers des cas.
Il s' est agit assez souvent de mesures d'inaptitude
temporaire destinées à pouvoir modifier un ou
plusieurs facteurs de risque, soit en introduisant un
régime, soit en instaurant un traitement. L'expérience
nous a montré que l'action sur l'aptitude des
intéressés était un moyen tout à fait efficace, chez
certains d' entre eux au moins, pour obtenir une prise
de conscience réelle du risque et un effet thérapeutique
sérieux. La persuasion seule est souvent inopérante ou
ne permet d' obtenir qu'une amélioration très
passagère.

DISCUSSION
Il convient tout d'abord d'insister sur la fréquence
des troubles lipidiques dans cette population de
navigants hospitalisés. Nous avons dénombré en effet
52,3% des sujets comme porteurs d'une élévation des
dosages lipidiques au dessus des valeurs retenues par
le consensus européen.Cette valeur est trés prôche de
celle rapportée dans une étude effectuée dans l' USAF
à partir de la mesure de la fraction LDL du cholesterol
(3). Et d'autre part, 31% se situaient au dessus des
valeurs considérées comme associées à un risque
majoré.Ceci apparait quantitativement considérable
quand on se rappelle la façon dont cette population a
été sélectionnée et surveillée.Néammoins il convient
de préciser que nous ne connaissons pas la valeur
moyenne du cholesterol des jeunes élèves pilotes.
Le groupe des controleurs, qui sont peut-être moins
sensibles à l' importance de la notion de risque
puisqu'il ne participe pas de manière directe au vol,
est celui qui proportionnellement est le plus atteint
avec 41,7% d'entre eux, alors que celui des élèves ne
comporte que 9,3% de sujets anormaux; ce qui est
plutôt rassurant.

Le niveau de l'action thérapeutique spécifique mérite
maintenant d' être discutée car le niveau d'
intervention global qui se situe à 44,6% des sujets
parait faible.
On peut avancer plusieurs types d' arguments pour
expliquer cette constatation.
Il faut tenir compte tout d' abord du mode de
recrutement de cette population qui est suivie parfois
pour des anomalies ou des pathologies importantes
qui rejettent un peu le problème métabolique dans
l'ombre , au moins pendant quelque temps.
Il peut également coexister chez le même homme
plusieurs troubles métaboliques ou plusieurs facteurs
de risque vasculaire avec la nécessité, parfois d'une

action thérapeutique multiple dans laquelle celle sur la dyslipidémie n'était pas privilégiée
Surtout on doit insister sur le niveau, en définitive, assez bas de la majeure partie des anomalies observées.Si en fréquence, le problème apparait important, il l'est beaucoup moins en niveau de gravité.
Il faut tenir compte de la notion, bien retenue par les médecins français, que le risque lié à ce type de facteur est sans doute plus bas dans nôtre pays que dans d' autres.Le bénéfice à attendre d'un régime n'est sans doute pas perçu de la même façon et la compliance thérapeutique moins effective.
Enfin on ne saurait négliger l'importance des plaisirs de la table dans nôtre population même navigante.

Une évolution dans un sens favorable est néammoins observée avec une réduction globale qui est mesurée aux alentours de 10 % pour les dosages du cholesterol et des triglycérides et de 8 % pour l'indice multifactoriel.Ceci peut paraitre quelque peu insuffisant mais en fait ne rend compte que des options les plus défavorables; en effet si l'intéressé ne pose qu' un problème de trouble métabolique corrigé par le traitement, il ne sera plus suivi dans le service et ne peut donc figurer dans cette étude.Les cas où l'efficacité a été probablement la plus grande sont ainsi perdus de vue.
Néammoins, 12 % de cette population a présenté un ou plusieurs évènements médicaux dans le domaine cardiovasculaire dont certains étaient graves mais asymptomatiques et découverts grâce à la prise en compte de l'anomalie lipidique. Ceci doit nous convaincre de l'intérêt d' un tel suivi éventuellement avec des marqueurs plus précis mais sans perdre de vue les difficultés rencontrées pour traiter cette population.

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HYPERCHOLESTEROLEMIE TOTALE (n=472) et à RISQUE (n=294)
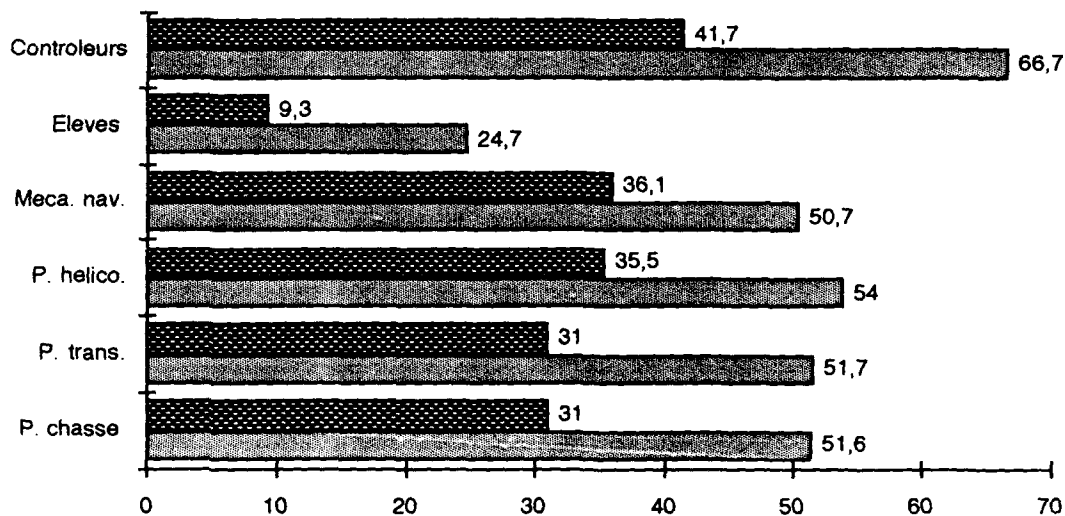POURCENTAGE DANS CHAQUE CATEGORIE DE P.N.

Figure 1

HYPERCHOLESTEROLEMIES A RISQUE
TRIGLYCERIDES   CHOLESTEROL   FACTEUR "C" (n=117)

moyennes: TRIGLY=1,73   CHOLEST=2,83   "C"=4,6

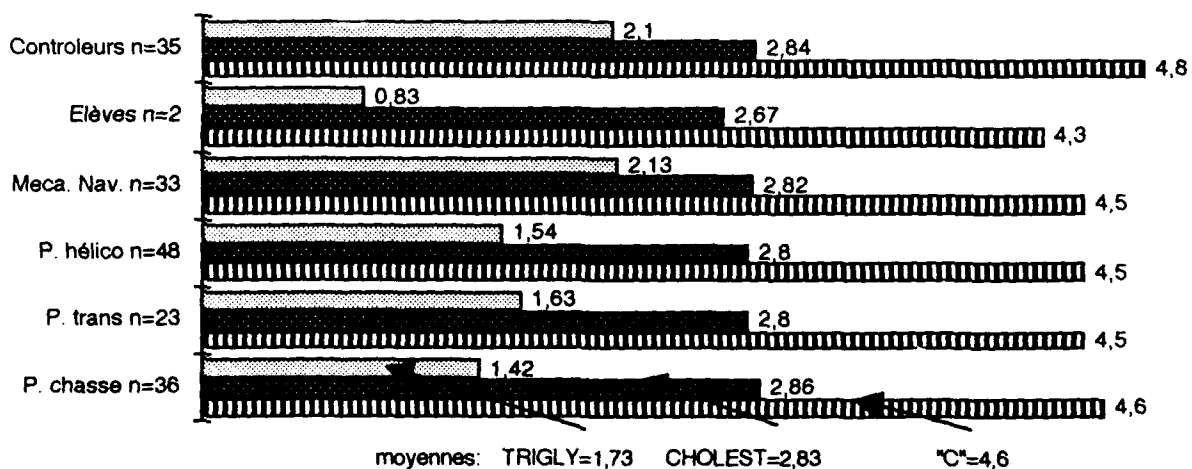Figure 2

Lipidemic Profile of Hellenic Airforce Officers

J. Palermos, A. Kitsou, S. Michalopoulou, K. Kyriakos

Hellenic Airforce and VA General Hospital and Center of Aviation Medicine.
Katehaki-Mesogion St, Athens 11525, Greece.

1. SUMMARY

To gain a better insight into the lipidemic profile of our personnel we measured chemically the serum concentration of total lipids, total cholesterol, triglycerides, phospholipids, high and low density cholesterol, A-1 and B apolipoproteins in 324 healthy ground officers. Additionally, we estimated the LDL cholesterol using the Friedewald's formula LDLfc = chol-HDLc-(trig/5)

The population under study, randomly selected, consisted of male, ground officers in active duty serving in the Hellenic Airforce with similar socio-economic status,without any history of coronary heart disease or diabetes mellitus and not receiving any medication. They were grouped into three groups (n = 108) of 31-35, 36-40, 41-45 years old.

A statistically significant increase in the blood concentration of total cholesterol, triglycerides, LDL cholesterol and apolipoproteinB were found in the 36-40 age group. A significant percentage of individuals in every age group, had blood lipid concentrations (cholesterol 41.7%, LDL-cholesterol 51.9%, triglycerides 7.1%, apolipoproteinA-1 43.8%) exceeding the desirable levels that prevent an increased risk of a coronary heart disease. Estimated LDLfc values were higher than the measured ones, but from regression analysis we found stronger relationship between LDLfc and total cholesterol. We did not find any correlation between HDLc and total cholesterol. Finally our results suggest that: 1) A high percentage of our ground personnel has blood lipid concentrations (principally chol, LDLc, apo-A1) exceeding the levels that prevent an increased risk of coronary heart disease (CHD). 2) People aged over 40 seem to be sufficiently aware of the risk of high blood lipid concentrations and this awareness has to be extended toward younger ages. 3) Certain lipids (phos, HDLc, apo-A1) do not vary among the age groups we studied and are possibly not discriminatory markers for the screening of lipidemic profile. 4) Estimated LDLfc, though higher than the measured LDLc, showed stronger relationship with total cholesterol and under restrictions can be considered as trustworthy index of the lipidemic profile.

2. INTRODUCTION

It is well established that increased blood cholesterol levels and specifically increased LDL cholesterol levels are causally related to an increased risk of coronary heart disease (CHD) (Ref 1). Such a blood cholesterol level increase is usually associated with aberrations in blood concentration of other lipids and is considered to be multifactorial.

Heredity, fat and cholesterol content of the diet, obesity, and physical inactivity are the major factors, among others, that determine the blood cholesterol level (Ref 2). It has become evident, through years of research, that lowering total and LDL cholesterol levels will reduce the incidence of CHD (Ref 3).

Recently, the Expert Panel of the National Cholesterol Education Program has established LDL cholesterol as the primary decision analyte in identifying subjects for treatment and recommended the cutpoints of 130 and 160 mg/dl as borderline and high risk concentrations, respectively. The major concern therefore, regarding blood cholesterol, is to shift the distribution of cholesterol level in the population to a lower range and to identify individuals at high risk for treatment (Ref 4).

The need for a better evaluation and classification of certain patients, as well as the monitoring of their treatment, call for further analysis based on the measurement of the total lipidemic profile, a process which is sometimes expensive and time consuming.

Several studies, which looked for the relationship between lipids and the correlation between different methods, have pointed out that there are variations in these relationships due to population age, life-style, ethnicity and to the various methods used.

To get better insight into our subjects' lipidemic status, among age groups, we evaluated blood total lipids (t. lip), cholesterol (chol), triglycerides (trig), phospholipids (phos), high and low density cholesterol (HDLc, LDLc), A-1 and B lipoproteins (apo-A1, apo-B), and estimated LDLc (LDLfc) by Friedewald's formula. The life-style features of the population under study are analysed elsewhere.

3. MATERIALS AND METHODS

3.1 Subjects

The population under study consisted of 324 healthy Greek male, ground officers, with similar socio-economic status, in active duty, who were going through their periodic medical examination at the Hellenic Airforce Center of Aviation Medicine, in Athens.

They were randomly selected, within a certain period, from among all officers between the age of 31-45. Individuals with any history of coronary heart disease,

Table 1. The results of the measurements (mean mg/dl, ±SD) per analyte and age group.

group	t.lipids	chol	trig	phos	HDLc	LDLc	LDLfc	apo-A1	apo-B
31-35	641(119)*	231(50)*	121(55)*	205(40)	42(7)	142(49)*	163(47)	120(18)	128(35)*
36-40	708(144)*	248(47)*	172(81)*	208(42)	40(8)	158(46)*	172(43)	119(19)	138(33)
41-45	655(116)	231(44)	131(57)	208(40)	42(8)	143(40)	162(41)	122(24)	131(30)
total	668(129)	237(48)	141(69)	207(41)	41(8)	148(46)	166(44)	121(20)	133(33)

* $p < 0.05$ by comparison of means of the analytes between consecutive age groups. chol = cholesterol, trig = triglycerides, phos = phospholipids, HDLc = HDLcholesterol, LDLc = LDLcholesterol, LDLfc = estimated LDLcholesterol by Friedewald's formula.

diabetes mellitus, high blood pressure, or receiving any medication were excluded from the study. The subjects were grouped into three age groups (n = 108) of 31-35, 36-40 and 41-45 and certain analytes were measured from blood serum that was drawn after overnight fasting, as follows:

3.2 Lipid analysis

Total cholesterol and triglyceride concentrations were measured enzymatically using a Trinder-type, and a GPO-PAP test without glycerol blanking method, respectively, employing a Technicon RA-1000 analyser. Total lipids were measured after dioxan-ethanol extraction and turbidometric determination in the presence of phenol (BIOTROL, FRANCE).

Phospholipids were assayed by a Trinder reaction after hydrolysis by phospholipase-D and measurement of liberated choline.

HDL-cholesterol was determined enzymatically by the CHOD-PAP method, after precipitation of apolipoprotein B-containing lipoproteins with phosphotungstate in the presence of magnesium (HDL-cholesterol precipitant, BIOMERIEUX-FRANCE).

LDL-cholesterol was measured enzymatically (CHOD-PAP) in the precipitated fraction, after treatment with amphipathic polymers and centrifugation (LDL-cholesterol precipitant, BIOMERIEUX-FRANCE).

Serum apolipoproteins A-1 and B were measured by a kinetic turbidometric peak-rate method employing a Behring turbitimer protein analyser.

Estimated LDL-cholesterol was calculated using the Friedewald's formula LDLc = Chol-HDLc-Trig/5. Our cholesterol and triglyceride assaying methods were standardised by being included in the Wellcome Clinical Chemistry Quality Assessment Program. The other methods were standardised by control sera (precinorm U, Precipath U and Lyotrol N) provided by the same manufacturer.

The day to day variation in precision during the study, given as the coefficient of variation of the control serum, ranged between 3% and 7% for all the analytes.

3.3 Statistical analysis

Mean values among the age groups were compared using the Student's paired t-test, while the Pearson's coefficient of correlation was used for regression analysis. For nonparametric variables the Spearman's coefficient of variation was employed.

4. RESULTS

Table 1 shows the means of the examined analytes in every age group. There is a statistically significant (p < 0.05) increase in the mean values of cholesterol, triglycerides, LDL-cholesterol and apolipoprotein B in the 36-40 age group, followed by a decrease in the next group of 41-45. This fluctuation of the means among age groups was also found in the calculated LDL-cholesterol and total lipids, but the later possibly reflects the changes in the constituents of total lipids (cholesterol, triglycerides).

It is noteworthy that though there is an upward shift in the mean values of cholesterol, triglycerides and LDL-cholesterol in the 36-40 age group, the respective SD values show a tendency to decrease as one moves toward older groups.

Table 2. The percentage of individuals with blood lipid concentrations exceeding the high risk limits.

	chol	trig	HDLc	LDLc	LDLcf	apo-A1	apo-B
21-35	37.0	3.7	13.9	26.9	50.0	42.6	14.8
36-40	54.6	14.8	25.0	47.2	58.3	49.1	25.0
41-45	33.3	2.8	17.6	27.8	47.2	39.8	18.5
Total	41.7	7.1	18.8	34.0	51.9	43.8	19.4

Phospholipids, HDL cholesterol and apolipoprotein A-1 do not change in healthy individuals in the age of 30 up to 45. Considering the recommended cutpoints, beyond which the blood lipid concentrations define a high risk for CHD, (total cholesterol > 240 mg/dl, triglycerides > 250 mg/dl, LDLc > 160 mg/dl, and HDLc < 35 mg/dl), a significant percentage of the studied individuals in every age group, had the measured analytes exceeding the cutpoints set (Table 2). For apo-A1 and apo-B, the reference ranges of 115-190 mg/dl and 70-160 mg/dl were used respectively.

In table 3 the lipidemic profile of individuals with elevated total cholesterol is shown. The increased cholesterol levels are mainly associated with an increased LDLc and apo-B, and decreased apo-A1 blood level.

The results of the linear regression analysis between certain analytes are tabulated in table 4

Table 3. The frequency of blood lipids exceeding the risk limits in individuals with high blood cholesterol.

	#	trig	HDLc	LDLc	LDLcf	apo-A1	apo-B
31-35	40	2	10	24	39	19	14
		(5%)	(25%)	(60%)	(98%)	(48%)	(35%)
36-40	59	13	12	44	52	27	26
		(22%)	(20%)	(75%)	(88%)	(45%)	(44%)
41-45	38	1	6	25	34	19	17
		(3%)	(15%)	(66%)	(90%)	(50%)	(45%)
Total	137	16	28	93	125	65	57
		(12%)	(20%)	(68%)	(91%)	(47%)	(42%)

There is high correlation between the examined analytes, except in the case of cholesterol versus HDLc and apo-A1, where it is evident that these analytes vary independently of each other. Interestingly, there is a variation in the intercept value (a) in the regression equation of certain analytes among age groups (t.lip. versus chol, chol versus LDLfc and apo-A1). In order to show how closely the coefficients of correlation (r) are related among age groups, the coefficient of determination (r squared) is depicted. A diminishing relationship can be found in the correlation of total lipids versus cholesterol, and apo-A1 versus HDLc in older people, as well as, a U-shaped relationship between cholesterol and LDLfc in the middle-aged group.

Table 4. The results of linear regression (Y = a + bX) between certain analytes among age groups.

analytes	age groups								
	31-35			36-40			41-45		
	a	r	r^2	a	r	r^2	a	r	r^2
T.lip vs chol	254	.7	50	198	.7	46	285	.6	36
T.lip vs trig	495	.6	31	500	.7	46	507	.6	31
chol vs HCLc	239	.0	0	242	.0	0	230	.0	0
chol vs LDLc	118	.8	60	118	.8	62	108	.8	62
chol vs LDLfc	65	.9	90	86	.9	74	70	.9	87
chol vs apo-A1	120	.0	0	107	.0	0	125	.0	0
chol vs apo-B	11	.7	53	26	.6	42	20	.7	49
LDLfc vs LDLc	59	.8	59	62	.7	53	40	.8	69
apo-A1 vs HDLc	46	.7	49	46	.8	66	57	.5	30
apo-B vs LDLc	62	.7	43	63	.7	43	52	.7	55

a = intercept, r = coefficient of correlation, r² = coefficient of determination, T.lip = Total lipids, chol = cholesterol, trig = triglycerides, HDLc, LDLc = HDL, LDL cholesterol, LDLfc = estimated LDL cholesterol, Apo-A1, Apo-B = apolipoproteins A-1, B.

Finally, the ratio (chol-HDLc-LDLc)/trig, which represents the ratio of VLDLc/trig and is indicative of the content of VLDL lipoprotein in triglycerides, was 0.44, 0.33 and 0.38 for the given age groups respectively.

5. DISCUSSION

Ground officers between the ages of 36 to 40 show a statistically significant increase in blood cholesterol, triglycerides, LDL cholesterol, and apo-B, in comparison with these of the 30-35 and 41-45 groups with similar lifestyle. In the 36-40 age group, the mechanism, through which the excess cholesterol is removed from circulation, seems roughly not to have been affected in comparison with the other groups (HDLc and apo-A1 not decreased versus them of the other groups). Because in the next group there is a downward shift in the cholesterol and triglyceride blood concentrations, it is reasonable to attribute this increase of lipids to the excess in food intake (Ref 5).

A significant percentage, in every age group we studied, had blood lipid concentrations exceeding the desirable levels that prevent an increased risk of CHD. Specifically, increased total and LDL cholesterol were found much more frequently than triglycerides (41.7%, 34.0%, 7.1%). It can be deduced that it is the high intake of cholesterol rich meals rather than the high caloric or fatty intake, that contribute to the hyperlipidemia of our population. The possible explanation we can propose is either badly scheduled dietary habits, or sedentary life-style. A study is in progress dealing with the analysis of nutritional factors concerning our personnel.

Regarding the distribution of the measured blood lipid concentrations, the older the age, the closer these values cluster about the mean of normal values. There is consequently a decrease in the number of outliers.

A large proportion (43,8%) of the examined population had blood apo-A1 concentration less than the assigned lower level of 115 mg/dl, a finding that could have an impact in the Lecithin:Cholesterol Acyltransferase (LCAT) activity which is responsible for the cholesterol esterification and reverse cholesterol transport from tissues to the liver. Apolipoprotein A-1 in HDLc is an activator of the plasma LCAT. The correlation of the decreased blood apo-A1 level and esterified cholesterol values in our population remains to be studied.

Hypercholesterolemia characterised by elevated LDL values has been designated as polygenic, constituting the type IIa phenotype. Our data suggest that the majority of our hyperlipidemic subjects belong to or resemble the type IIa lipoprotein pattern.

Estimation of LDLc by Friedewald's formula, where VLDLc = trig/5, tends to give higher results for LDLfc versus the measured ones, but since LDLfc has a better concordance with total cholesterol after the correlation of HDLc, LDLc and LDLfc fractions with the total cholesterol, it can be considered as a trustworthy index of the lipidemic profile.

The Friedewald's formula cannot accurately be used without certain restrictions (Ref 6). Warnick et al have demonstrated that for those who measure triglycerides without blanking correction, a slightly larger than 5 (tri/5) denominator might be appropriate due to an overestimation of triglycerides (Ref 7).

The reliability of the LDLc estimations decrease considerably with increasing triglyceride concentrations,with the cutpoint set at 400 mg/dl.

The formula assumes that the cholesterol/triglycerides ratio of Very-Low-Density-Lipoprotein is roughly constant and that all triglycerides are from VLDL (Ref 8). Hence the ratio VLDLc/trig is indicative of the content of VLDL lipoprotein in triglycerides, because when chylomicrons are not detectable most of the triglycerides in plasma are contained in the VLDL. In patients with type III hyperlipoproteinemia which is characterised by cholesterol enrichment of VLDL, the formula gives erroneously high results.

In the VLDLc/trig ratio among age groups there is a slight variability that is expected to cause at most a 7 to 10% error in LDLfc values,as has been established by others (Ref 9,10,11). In our results, LDLfc values have presumably been slightly overestimated, because type III hyperlipidemic individuals have possibly been included in our subjects, while the measured LDLc values have been underestimated due to artefacts in our LDL assaying procedure.

Finally the blood HDLc concentration cannot be employed as an index of cholesterol's variation and vice versa.

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Blood Lipids in Aircrew Recruits and in RAF Aviators

D. H. Hull, Air Cdre, RAF
Consultant Adviser in Medicine, RAF
RAF Central Medical Establishment
Kelvin House, Cleveland Street
London W1P 5FB, United Kingdom

SUMMARY

Blood cholesterol is a major indicator of cardio-vascular risk, mainly from coronary artery disease. Blood lipid elevations are a common cause for referral of RAF aircrew for specialist assessment. The need for investigation, treatment (dietary, drugs), repeated counselling and indefinite follow-up constitutes a significant commitment.

Blood lipids were measured in fasting male subjects from two groups; young recruits provisionally accepted for RAF flying training, and trained RAF aircrew. Mean blood cholesterols (SDs) were 4.65 (0.89) mmol/l (180 (34) mgm/dl) in recruits and 5.5 (1.14) mmol/l (213 (44) mgm/dl) in trained aircrew. Corresponding figures for triglycerides were 1.13 (0.56) mmol/l (100 (50) mgm/dl) in recruits and 1.46 (0.86) mmol/l (129 (76) mgm/dl). All differences between groups were significant (p <.001). Lipid levels were correlated with age in both groups.

Blood lipid levels in recruits were in general satisfactory; the main purpose of measurement remains the detection of the occasional individual with a familial hyperlipidaemia. Blood cholesterols in trained aircrew, though lower than the average for British men, were above desirable limits in 50% of all aircrew tested. 10% were in the band requiring clinical care and 2% might require drug treatment.

A programme to reduce cardiovascular risk in RAF personnel will include dietary, exercise and other measures.

1. INTRODUCTION

High blood cholesterol is a major risk factor for coronary artery disease, and to a lesser extent for other vascular diseases (1, 2). In general, the risk increases progressively with increasing levels of blood cholesterol (3), with some evidence of a disproportionate increase in risk at higher levels (2). Low density lipoprotein cholesterol is more closely correlated with risk than is total cholesterol (4); however, because the greater part of total cholesterol is composed of the low density cholesterol fraction in nearly all individuals, total cholesterol is itself a reasonable measure of individual risk (5, 6). The significance of a given level of fasting triglyceride is less certain, but very high levels add to vascular risk and are associated with other disorders (4).

In the Royal Air Force, measurement of blood lipids is carried out regularly in trained aircrew, and as part of the initial medical screening of recruits for flying training. Recruits with abnormally raised blood lipids are not accepted for aircrew duties. Hyperlipidaemia discovered in trained aircrew is a common reason for further assessment and counselling by flight medical [...] specialist referral and for further

investigation. If non-pharmacological measures fail to correct hyperlipidaemia, drug greatment is quite often required. Familial hypercholesterolaemia and familial combined hyperlipidaemia are considered incompatible with a full flying category. A diagnosis of coronary artery disease results in permanent grounding.

This paper presents the results of blood lipid screening of recruits and of RAF aircrew over a one-year period in 1990.

2. SUBJECTS AND METHODS

The subjects of this study were recruits and trained aircrew. The recruits had all been provisionally accepted for RAF flying training. The trained aircrew were all fully qualified RAF aviators on current flying status. All members of both groups were male. The Table gives descriptive statistics of both groups.

The recruits were nearly all young men, only 24 (5%) of the total of 477 being 27 years old or more. The trained aircrew were on average 14 years older than the recruits, and showed a much wider age distribution, apparently bimodal (Figures 1-3). The educational and social backgrounds of the two groups were closely similar, most being university or college graduates or currently undergoing higher education. Though no formal comparisons were made, there is no doubt that both groups, by selection and other factors, enjoyed superior health and fitness standards compared with the general population.

TABLE

	Recruits	Trained aircrew
n	477	2521
Age	21 (4)	35 (10)
Cholesterol (mmol/l)	4.65 (0.89)	5.5 (1.14)
Triglyceride (mmol/l)	1.13 (0.56)	1.46 (0.86)

Caption: Comparison of recruits and trained aircrew. Figures are group means (SDs). All differences between groups are significant (p<.001).

Blood samples from both groups were drawn in the morning, after a ten-hour fast. Total blood cholesterol and triglyceride were measured by standard laboratory techniques, using enzymatic methods in autoanalysers. All the recruit samples, and the great majority of the trained aircrew samples, were analysed in laboratories at military hospitals or the RAF Institute of Pathology and Tropical Medicine. The remaining samples were sent to laboratories in civilian hospitals in the U.K. (No numerical comparison of results from different laboratories was made, but there was no sign of an

systematic differences in the results. Military and civilian laboratories participate in a national quality control programme involving frequent "blind" assays of standard test samples.)

3. RESULTS

These are shown in the Table and in Figures 4-9.

In the recruits, average blood cholesterol was 4.65 mmol/l (180 mgm/dl), range 1.3-8.0 mmol/l (50-310 mgm/dl), and triglycerides 1.13 mmol/l (100 mgm/dl) range 0.3-6.0 mmol/l (27-531 mgm/dl). There were weak positive correlations with age for both cholesterol (correlation coefficient 0.3) and triglycerides (correlation coefficient C.1). In the trained aircrew, average blood cholesterol was 5.5 mmol/l (213 mgm/dl), range 0.49-9.0 mmol/l (19-348 mgm/dl) and triglycerides 1.46 mmol/l (129 mgm/dl) range 0.49-7.0 mmol/l (43-620 mgm/dl). Coefficients of correlation of cholesterol with age (0.42) and triglycerides with age (0.21) were positive.

The trained aircrew had higher blood cholesterols and triglycerides than the recruits, and these differences were significant (p.<.001). The positive correlation of both cholesterol and triglyceride with age was more marked in the trained aircrew than in the recruits, and the variability of measurements a little greater, but these differences may have more to do with the larger number of subjects in the trained aircrew group than true differences between youth and middle age.

Distributions of blood lipid levels in recruits resemble normal curves though there is a small "tail" of higher values leading to slight skewing of the curves. Distributions of lipid values in trained aircrew show rather more marked skewing to the right, due to a larger proportion of high values of both cholesterol and triglycerides. The effects of age and of "skewing" mean that hyperlipidaemia is far commoner in trained aircrew than in recruits; more than six times as many trained aircrew have blood cholesterols higher than 6.5 mmol/l (252 mgm/dl) than do recruits (18.8% vs 3%).

4. DISCUSSION

The average level of blood cholesterols in the recruits (4.65 mmol/l, 180 mgm/dl) was lower than figures for comparable age-groups of UK public employees (5) and UK city dwellers (7) and similar to the levels in the youngest applicants (22-24 years old) for airline pilot training in the USA (8). Most recruits had blood cholesterol levels well within desirable limits according to best current advice (4, 9, 10). Their blood triglycerides were nearly all within the normal range and well below the British average for young men (5, 7).

The average blood cholesterol of trained aircrew (5.5 mmol/l, 213 mgm/dl) is lower than that of men in three out of four British cities and in 24 British towns (11, 12), though comparable with the average in men aged 25-59 years in London (7). It is higher than the average in any age group amongst airline pilot applicants in the USA (8) or in several thousand male Minnesotans (13)

though similar to that of a small number of US military pilots (14), and to the large male population of the Multiple Risk Factor Intervention Trial (2), though the latter figures are now nearly 20 years old.

Blood triglycerides (average 1.46 mmol/l, 129 mgm/dl) were lower than those of most British men (5, 7) and comparable with those of USAF pilots (14). There were, however, a number of high values, 18% being 2.0 mmol/l (177 mgm/dl) or above and 5.3% being 3.0 mmol/l (266 mgm/dl) or above.

Most published data suggest that average blood cholesterols are higher in the UK than in the USA. Moreover, the progressive decline in blood cholesterol levels seen in the past twenty years in the USA (13, 15) appears not to have occurred in the UK (7), which may help to explain the persistently higher morbidity and mortality from coronary disease in the UK, compared with other nations. Although the UK has enjoyed some improvement in mortality from coronary disease over the past decade (16), the improvement has been less than and later than that seen in other communities (7, 15, 17), and this also seems likely to be related to the persistence of high blood lipid levels.

In the present study, recruits showed lower blood cholesterols and triglycerides than trained aircrew. This might be early evidence of a secular decline in lipid values in the population, although, as noted above, there is no supporting evidence for such a trend from other studies in the UK. It seems more likely that RAF aircrew, who have generally satisfactory blood lipid levels at selection, show a progressive rise in levels with age. Though the average rise is less than 1 mmol/l (39 mgm/dl) it is sufficient to result in over half the trained aircrew having blood cholesterols above the optimum level (5.2 mmol/l, 200 mgm/dl) determined by the British Cardiac Society Working Group on Coronary Prevention (10), the British Hyperlipidaemia Association (9), and the National Cholesterol Education Program Expert Panel (4) in the USA. According to the criteria of both the British Hyperlipidaemia Association and the Expert Panel, more than 50% of trained aircrew require professional counselling, dietary advice and follow up. Over 10% need "clinical care" according to advice of the British Hyperlipidaemia Association, whilst 2% may require drug treatment by the protocols of both the Working Group (10) and of the Hyperlipidaemia Association (9). The number requiring drug treatment according to the Expert Panel's criteria cannot be estimated from our data because low density lipoprotein cholesterols were not measured. However it is clear that, according to best current advice, at least half of trained aircrew have blood cholesterol levels at which they should receive expert advice, altered diets and life-long follow-up. Over one in ten need detailed assessment including specialised cardiological investigation. Some of these will require invasive studies; demonstration of coronary disease necessitates grounding. Of those able to retain flying status, an appreciable number will require drug treatment, itself a potential though unquantifiable hazard to individual well-being and to flying safety.

It is clear that present levels of blood lipids in trained RAF aircrew do not allow complacency. Changes in diet, in body weight, exercise and other habits that affect coronary risk would

appear highly desirable. The UK government has set a target of a 40% or better reduction in the death rate from coronary heart disease in England by the year 2000 (16). Such an achievement will require major changes in the dietary and other habits of the population. The Royal Air Force, with a fairly small aircrew cadre enjoying potentially optimal living conditions, should be able to contribute its full share to this endeavour. An official programme to promote improved physical fitness by regular exercise, dietary changes and tobacco restriction is now being implemented.

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AGE DISTRIBUTION OF AIRCREW RECRUITS
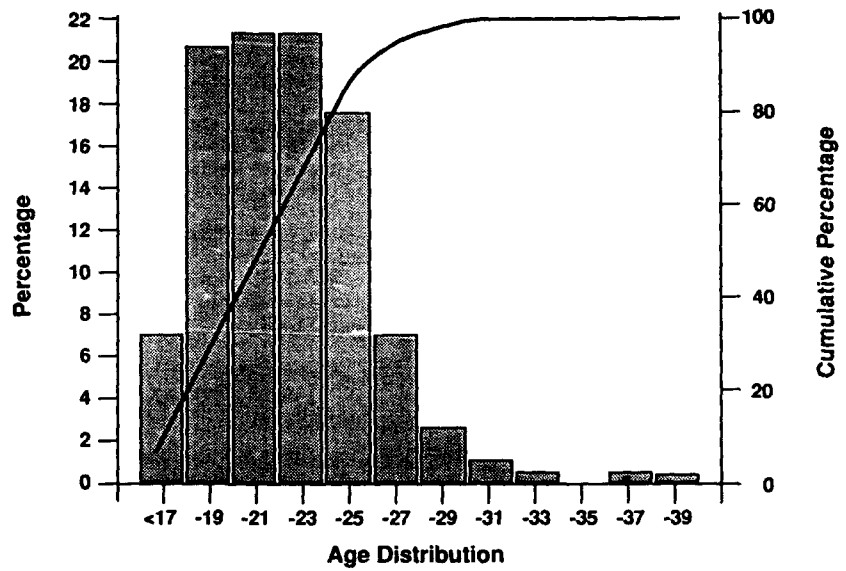
FIGURE 1

AGE DISTRIBUTION OF RAF AVIATORS
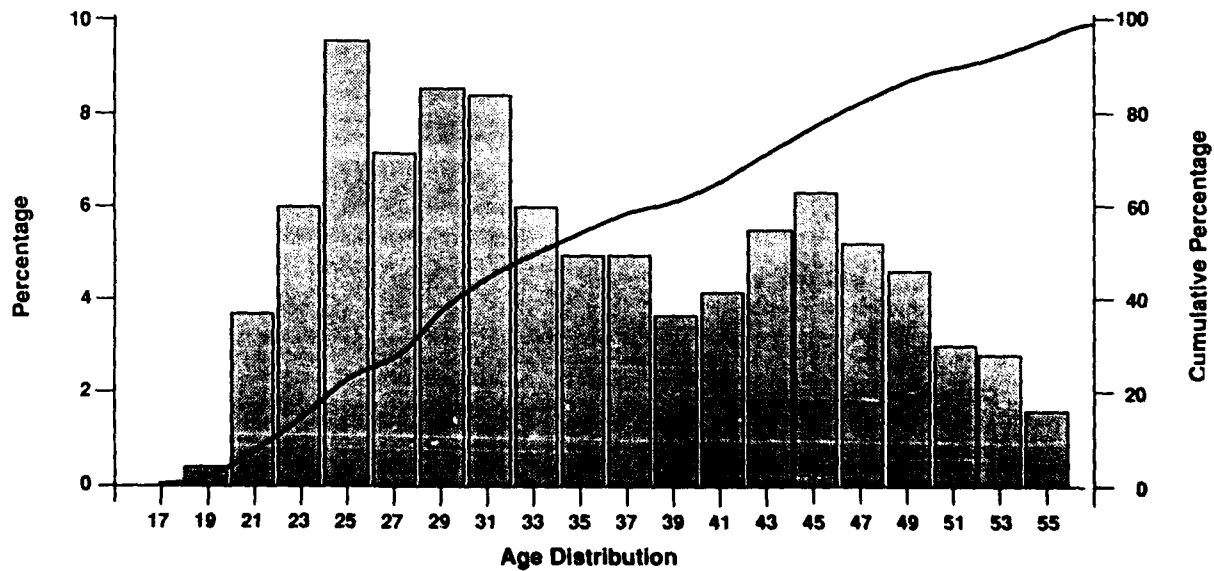
FIGURE 2

AGES OF AIRCREW RECRUITS AND RAF AVIATORS

FIGURE 3

BLOOD CHOLESTEROLS OF AIRCREW RECRUITS

FIGURE 4

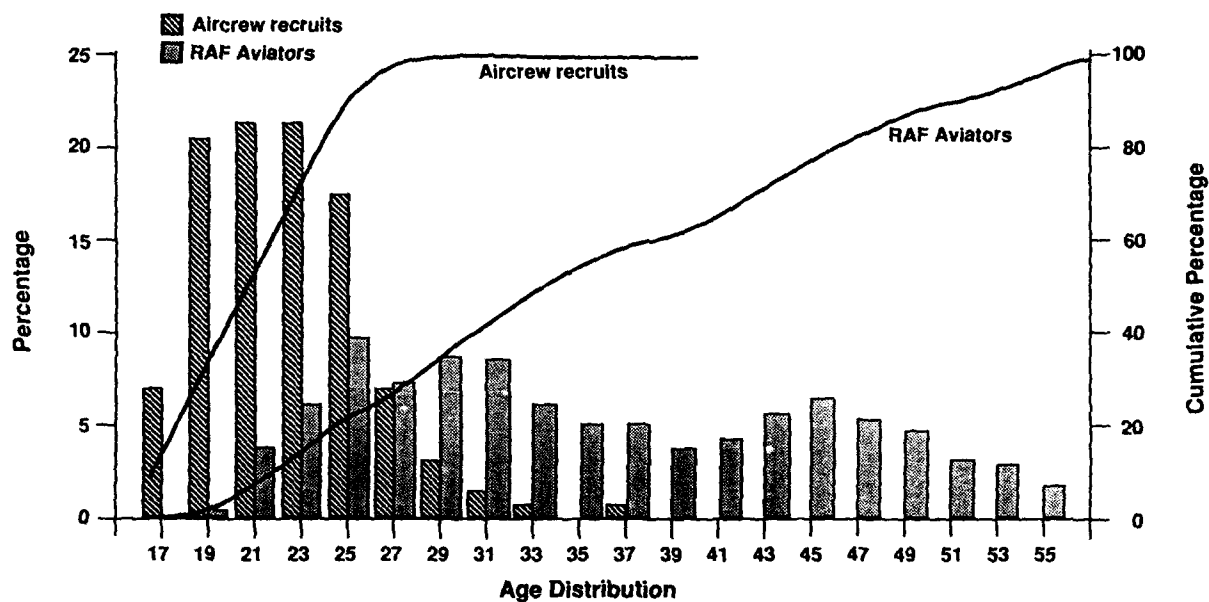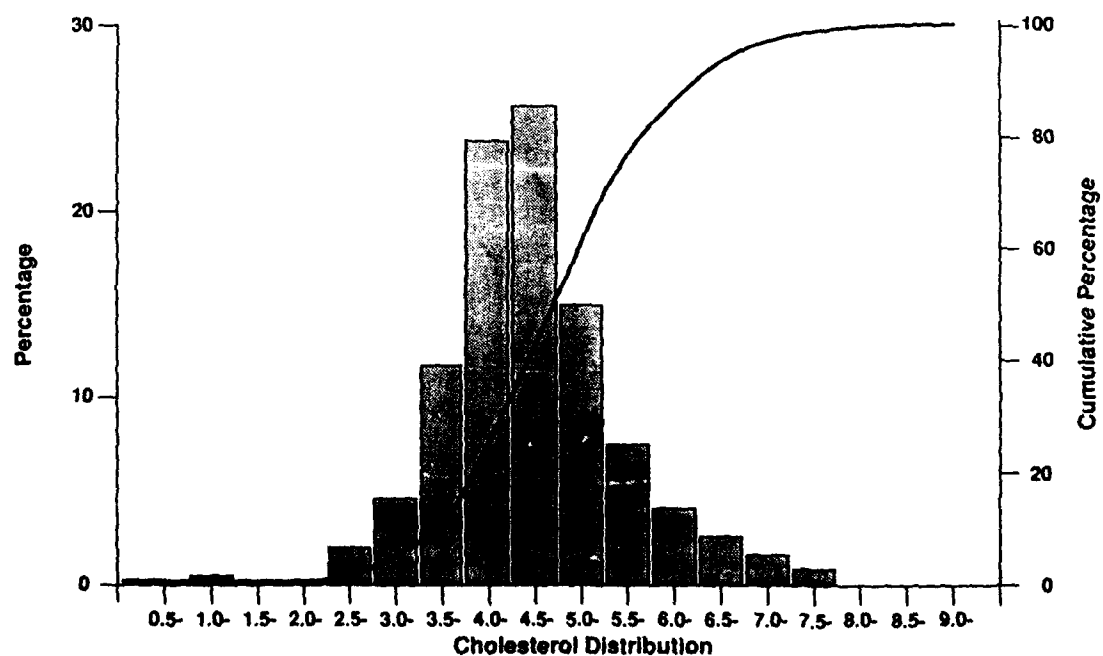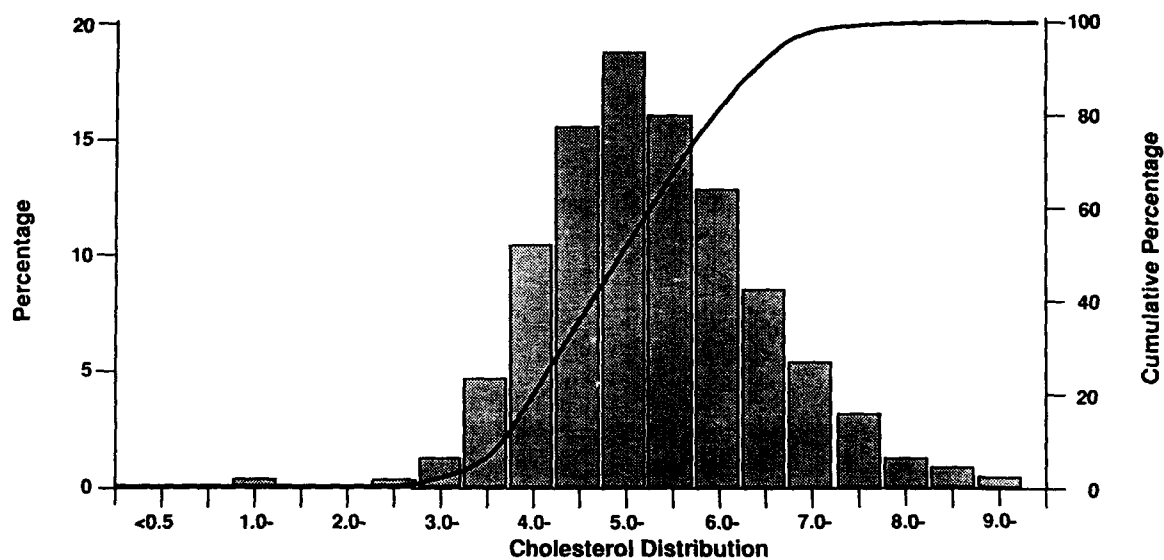# BLOOD CHOLESTEROLS OF RAF AVIATORS

FIGURE 5

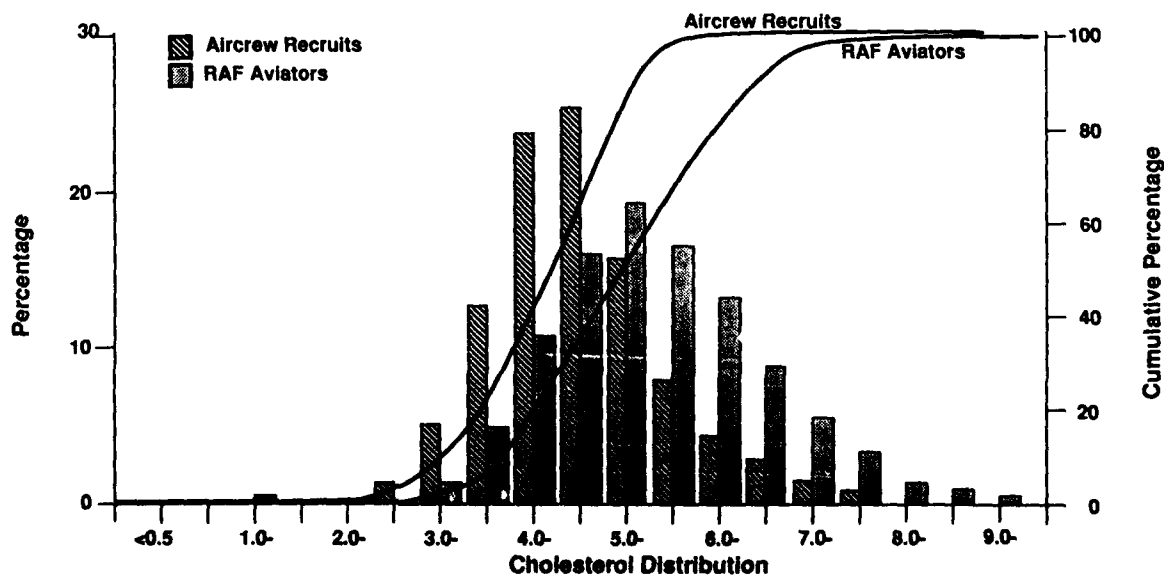# BLOOD CHOLESTEROLS OF AIRCREW RECRUITS
AND RAF AVIATORS

FIGURE 6

BLOOD TRIGLYCERIDES OF AIRCREW RECRUITS
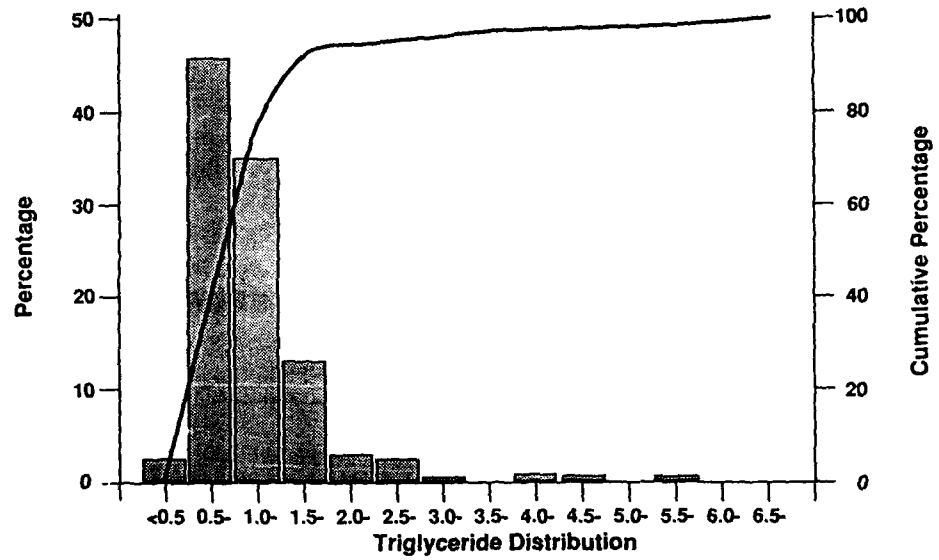

F I G U R E   7

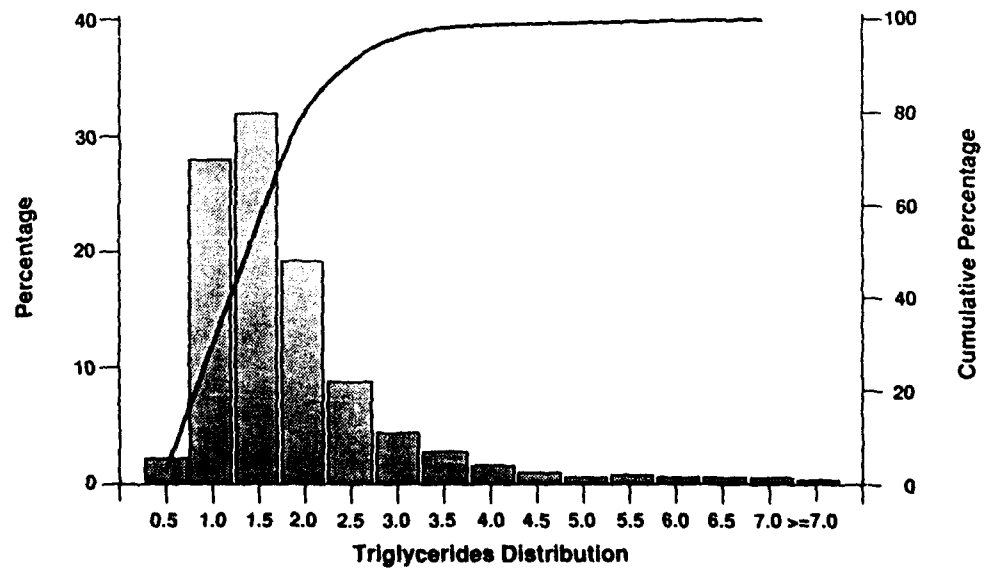**BLOOD TRIGLYCERIDES OF RAF AVIATORS**

F I G U R E   8

BLOOD TRIGLYCERIDES OF AIRCREW RECRUITS AND RAF AVIATORS
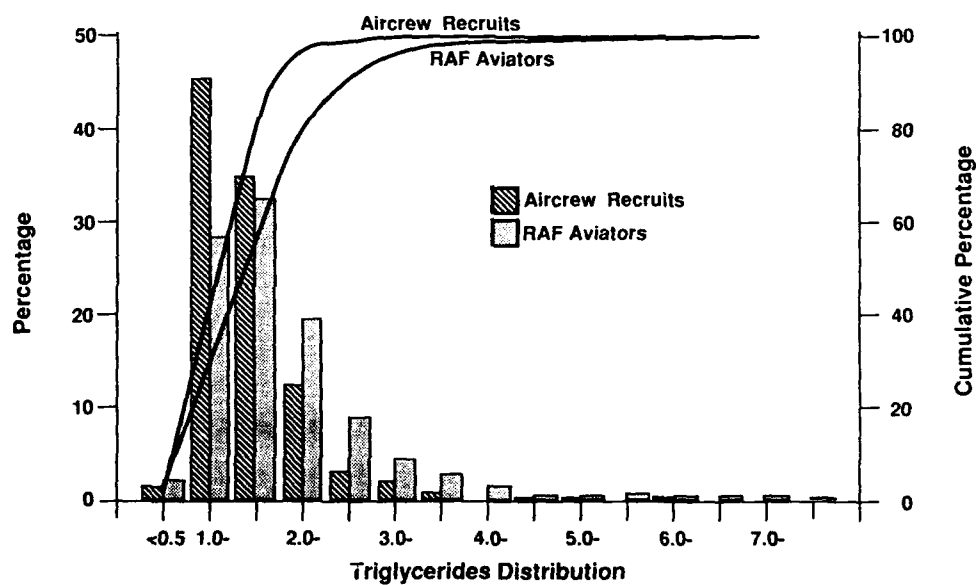
FIGURE 9

Cardiovascular Risk Factors in an Italian Air Force Population: Preliminary Report

S. Farrace; L. Sakara; L. Urbani; C. De Angelis
Italian Air Force- D.A.S.R.S. - Medicine Dept.
Pratica di Mare AFB - OOO40 Pomezia (RM) Italy

Abstract

Two hundreds male subjects from an Italian Air Force AFB were admitted after informed consent to an epidemiological study on the diffusion of cardiovascular risk factors. They were divided in two groups: group A (n=150; aged 37.7±10.7 yr.) was personnel mainly employed in logistic and administrative activities, group B (n=50; aged 35.2+⁷ ³) were pilots regularly performing flight activ. . Each subject underwent a clinical examination, height and weight , resting ECG and blood pressure recording, as well as a 20 ml blood sampling. Measurement of total cholesterol, HDL-cholesterol, glucose, uric acid, APO-A, APO-B and Lp(a) lipoprotein concentration was carried out in each subject. Data showed that while lipid values and mean arterial pressure (MAP) levels are significantly lower in group B (p<0.05) as compared to group A, APO A/B ratio and Lp(a) lipoprotein concentration are significantly higher (p<0.05). These findings may suggest that, despite a lipid profile and mean MAP level within the physiological range and independently from these parameters, it may be recognizable in the pilot group a trend towards atherosclerosis development which needs to be further investigated.

Introduction

It has been reported by several authors (1-8) that individuals who present, with different possible associations cardiovascular risk factors (CRF) may be involved with a variably increased incidence, in the onset of coronary heart disease as well as other life threatening conditions such as myocardial infarction. Among these factors some primary factors such as hyperdislipidemia, hypertension, glucose intolerance and diabetes, smoking habits and obesity are recognizable as major risk factors (9). Furthermore increased incidence of cardiovascular pathology and particular coronary hearth disease has been also related to the presence of a stressful life style.(10-16). Thus, considering some peculiarities of the military environment as regard to specific performances characterized by high workload together with an incidence of CRF that would possibly resemble that of the civilian population , it may result of interest to investigate whether or not the diffusion of cardiovascular risk factors is increased in the military community compared to a civilian population, and if there is any significant difference, within the military community, between categories where the kind of duty is at a different level of workload, with special regard to flight activity.

Therefore the aim of the present study was to investigate the frequency and diffusion of CRF in a population of an Italian Air Force base and to compare the results with the values reported for the Italian civilian population and, within the study population, between personnel involved or not in regular flight activity.

Methods

A total number of 200 male subjects were admitted after informed consent to the study. One hundred and fifty out of 200 (group A) were personnel whose duties were mostly represented by administrative and logistic activities. The remaining fifty subjects (group B) were pilots performing regular flight activity. All subjects were asked to withdraw drugs and/or medications 5 days before the study, with special regard to lipid and blood pressure lowering therapy.

Study design. All subjects underwent, after a preliminary clinical examination, to the following exams: weight and height recording, blood pressure measurement and resting ECG recording after 10 min of clynostatism, 20 ml blood sampling. Afterwards all subjects were asked to fill in a questionnaire about family and personal clinical history and personal alimentary habits, lifestyle and type of duty performend in the Air Force; all the examinations reported above were always carried out in the same order.

Analytical procedures . Blood samples were collected in 2 different aliquotes in tubes containing EDTA-K$_3$ and in syliconated tubes and placed in an ice bath ; they were than centrifuged (3,000 rpm for 15 min) within 1 hour. Total cholesterol, HDL-cholesterol, triglicerids, uric acids were determined by spectrophotometry (Refloton system, Bohering Mannheim, I) on serum from EDTA-K3 tubes immediately after centrifugation, while small amounts of plasma from syliconated tubes was used to determine glucose concentration by glucose oxidase method (Glucose Analyzer II, Beckman, Palo Alto, CA). The remaining part was stored at -80°C for later assayed of A-apolipoprotein (APO-A), B-apc''poprotein (APO-B) and Lp(a)-lipoprotein (Lp(a)); APO-A and APO-B analysis were carried out by nephelometry (ICS Analyzer, Beckman, Palo Alto, CA) and Lp(a) by ELISA, using commercially available kits (Bouty, MI, I).

Calculation: LDL cholesterol was calculated using the formula of Friedewald [LDL-cholesterol = (total cholesterol - HDL cholesterol + triglicerides/5)] ; left ventricular hypertrophy was calculated according to the Sokolow method ("S" wave amplitude in V$_1$ plus "R" wave amplitude in V$_5$; if the obtained value is > 35

mm it is considered suggestive for left ventricular hypertrophy); risk index was calculated in each subject by adopting an empiric method which assigned to each parameter (i.e. blood pressure and ematochemical values, as well as lifestyle, smoking habits and previous familiar history of cardiovascular disease) a number from 1 to 4 as depicted in table 2. A risk index equal to 11 was chosen as the cut off point between low and middle risk levels, while those indexes scoring above 21 were defined as "high risk". *Statistic*: data are presented as mean ± SEM. Analysis of variance was performed for statistic evaluation. Significant differences between groups (when $p<0.05$) were calculated by adopting the Bonferroni's test. All calculations and statistic evaluations were performed on Primer IBM compatible software package.

Results

Characteristics of subjects, as divided in group A and B, are reported in table 1. Evidence of electrocardiographics signs of left ventricular hypertrophy was present in 10.6 % of group A and in 11 % of group B (p=NS). Blood pressure values reported as mean arterial pressure (MAP) were 96.4±1.1 mmHg in group A and 90.9±1.4 and mmHg in group B (B significantly lower compared to A with $p<0.05$). (fig. 1). Data regarding serum levels of total, LDL, HDL cholesterol as well as uric acids and plasma levels of glucose are reported in table 4, while in table 3 data on APO-A, APO-B, APO-A/B ratio and Lp(a) in group A and B are shown. All lipid parameters as well as plasma glucose concentration resulted significantly lower ($p<0.05$) in group B compared to group A. Serum total cholesterol concentration was higher than 200 mg /dl in 44 subjects (30.11%) of group A and in 11 (24.99%) subjects of group B. Based on the results reported above as well as on information deduced from questionnaires risk index in group A was higher than 11 in 43 subjects (28.6%) and higher than 21 in 2 subjects (1.3%) while in group B 8 out of 50 subjects displayed a risk index higher than 11 (16%) and nobody in this group reported risk index higher than 21. A positive significant ($p<0.05$) correlation (fig. 2 and 3) was found between BMI and MAP in both group A and B.

Table 2

Empiric method adopted for the assignation of the Cardiovascular Risk Index (CRI) in subjects of group A and B (CRI = algebraic sum of all the single coefficients reported below, depending on the category matched by subjects).

Parameter	Categories	Coefficient
Serum Cholesterol (mg/dl)	<200 >200 >250	0 2 4
Serum Triglicerides (mg/dl)	<150 150-200 >200	0 1 2
Serum HDL Chol. (mg/dl)	>35 <35	0 2
Serum Uric Acids (mg/dl)	>8.0 <8.0	1 0
Plasma Glucose (mg/dl)	>120 <120	0 2
Mean Arterial Pressure (mmHg)	>100 100-160 >160	0 2 4
Body Mass Index (Kg/m2)	<25 25-27 >27	0 2 4
Smoking habit (No./day)	None <10 >10	0 2 4
History of Cardiovascular Disease (No. of Relatives)	None 1 2	0 2 5
Regular Physical Exercise (Frequency)	Never Sometimes Regularly	0 1 2

Table 3

Serum concentration of apolipoprotein A and B and lipoprotein (a) as well as A/B ratio in group A and group B subjects.

	Group A (n=150)	Group B (n=50)
Apoprotein A (mg/dl)	111.9±3.1	109.2±3.3
Apoprotein B (mg/dl)	94.7±5.4	105.2±4.0
Apo. A/B ratio (mg/dl)	1.3±0.1	1.1±0.07*
Lipoprotein(a) (mg/dl)	7.29±0.42	10.4±1.1*

*= $p<0.05$ compared to group A

Table 1

Characteristics of subjects in group A and B

	AGE (years)	SEX	BMI (kg/m2)
Group A (n=150)	37.7±10.8	All Males	25.7±0.26
Group B (n=50)	35.2±7.8	All Males	24.8±2.7

Table 4

Twenty four hours fasting serum total, LDL, HDL cholesterol, triglicerides, uric acids and plasma glucose levels in group A and group B subjects.

	Serum Total Cholesterol (mg/dl)	Serum LDL Cholesterol (mg/dl)	Serum HDL Cholesterol (mg/dl)	Serum Triglicerides (mg/dl)	Serum Uric Acids (mg/dl)	Plasma Glucose (mg/dl)
Group A (n=150)	204.8±2.1	141.6±1.9	36.2±0.7	134.6±3.7	5.94±0.7	93.9±1.1
Group B (n=50)	199.2±1.2*	138.6±1.6*	38.3±1.2*	111.5±1.2*	5.12±0.12*	88.9±1.2*

*= $p < 0.05$ compared to group A

Table 5

Comparison among total cholesterol and triglicerides serum concentrations and mean arterial pressure in group A, group B and the general italian population (16)

	Group A	Group B	Italian population
Total cholesterol (mg/dl)	204.8±2.1	199.2±1.2 *	221±0.84 (16)
Triglicerides (mg/dl)	134.6±3.7	119.4±2.8 *	132.9±2.0 (16)
Mean arterial pressure (mmHg)	96.4±1.1	90.9±1.4 *	100.6±2.1 (16)

* = $p < 0.05$ compared to group A and the Italian population

Fig.2-Correlation plotter between BMI (Body Mass Index) and MAP (Mean Arterial Pressure) in group A subjects.
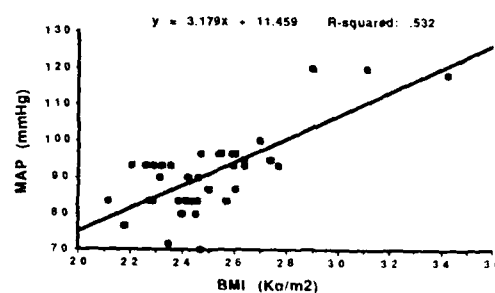
Fig.3-Correlation plotter between BMI (Body Mass Index) and MAP (Mean Arterial Pressure) in group B subjects.

Fig.1-Mean arterial pressure (MAP) in group A and group B subjects (*= $p < 0.05$ compared to group A).

Discussion

Total cholesterol and triglicerides concentrations in the Italian general population as well as mean blood pressure was reported in 1987, as mean values collected in 9 different populations all over the whole national area (16). Comparing our data with those reported for the Italian population (table 4), as regard to total cholesterol and triglicerides concentration and mean arterial pressure, they are significantly lower. Particularly data related to group B subjects (pilots), are significantly lower versus both group A and the Italian population. Thus as far as it concerns some major risk factors like cholesterol and triglicerides concentrations or blood pressure, they are not increased in frequency in the pilot population. Moreover they are within the physiological range. Furthermore data regarding plasma glucose concentration and uric acids concentration showed a significantly lower value in group B compared to group

A. Since these values are depending, unless specific pathology is involved, essentially from the lyfestyle, we may speculate that pilots might be more aware than controls in keeping life habbits under controlled conditions. The positive correlation that we found between BMI and MAP in both groups A and B, is consistent with wath previously observed by other authors (17, 18). In 1963 it was reported by Berg K.(19) of a newly discovered lipoprotein in human blood which was than defined as lipoprotein Lp(a). This latter, structurally similar to plasminogen (20), has been shown to represent an independent risk factors for cardiovascular disease and a possible role of this lipoprotein in the pathogenesis of atherosclerosis has been suggested by several authors (21-25). Focusing on our results, as shown in table 5, serum concentration of Lp(a) resulted significantly higher in pilots. Although the concentrations "at risk" for Lp(a) are reported to be above 20 mg/dl, nevertheless the significant higher value found in pilots group remain an interesting finding. Furthermore the apolipoprotein A/B ratio, which has been reported as a reliable marker of atherosclerotic risk (9), resulted significantly lower in pilots group. It indicates an increased concentration of apolipoprotein B in group B, which in turn reflects a relative increase in LDL.

These findings depict a situation where if on one side some parameters of not secondary importance (i.e total and HDL cholesterol, triglicerides, glucose and uric acids concentrations as well as mean blood pressure values) are within the normal range in pilots, on the other some parameters such as Lp(a) and Apo A/B ratio, which are markers of possible development of atherosclerosis, are significantly increased in the same group, compared to group A subjects. Moreover these latter parameters must be carefully considered becouse they may represent "independent" risk factors despite the normality of the others.

Therefore we conclude that with regard to major cardiovascular risk factors, their frequency is not increased in our population of pilots, that seems to be more healthy as compared to controls of group A. Beside some other parameters such as the increased Lp(a) concentration and the decreased APO A/B ratio may suggest in pilots a trend toward atherosclerosis which cannot be seen in group A subjects.

The pathophysiological mechanism underlying these findings is not carried out by this study and it needs to be further investigated. Finally, since these data are relative to a still small number of subjects, they need to be confirmed by a larger sample.

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CARDIOVASCULAR RISK FACTORS (CVRF) IN SPANISH PILOTS WITH CORONARY ARTERY DISEASE DEMONSTRATED BY ANGIOGRAPHIC STUDIES

by

M.A. Gómez-Marino, C. Alonso and F. Rios
Centro de Instrucción de Medicina Aeroespacial (C.I.M.A.)
C. Arturo Soria 82
28027 Madrid
Spain

SUMARY:

During the years 1987-1991, 32 spanish pilots with ages between 39 and 56 years (47.34±4.81), had demostrated coronary obstructive lesions by means of coronary angiography. Each case has been studied investigating separately, the following CVRF: cigarrete smoking, hypercholesterolemia, hypertrigliceridemia, diabetes, arterial hypertension, obesity and coronary disease family history. We found that CVRF were present in all the spanish pilot with proved coronary artery disease. 87.5% were heavy smokers and 68.5% had high levels of plasma cholesterol. The smoking habit was the most important single CVRF, even more than cholesterol high levels, but they may be relationed with the very high number of cigarrettes smoked (33.2±1.5 for a period of 24.7±6.3 years). Other CVRF were of little value if no associated to hypercholesterolemia or smoking habit. A proper control of CVRF it should be a priority over the pilot population in order to increase fligth safety and the efficiency of the air operations.

INTRODUCTION:

Coronary Artery Disease (CAD) along with cerebrovascular diseases are responsible for more than 50% of deaths in developped countries (1).

Even more, 50% of the mortality due to CAD, are sudden death (2). 25% of the patients with CAD, present as a first symptom sudden death, and 90% of all of sudden death, happened in patients with demostrated obstructive CAD (3-6).

These problems make difficult the evaluation of CAD, specially when symptoms are not present or they are hidden by the pilot in order to keep the flying status.

The close relation existing between CAD and Cardiovascular Risk Factors (CVRF) is well know, so that we must focus our attention in the early detection and control of the CVRF as the most important way of primary prevention of CAD (7-9).

The purpose of this paper is to review the presence of CVRF in aircrew members in which obstructive arteriosclerotic CAD has been demonstrated by angiography.

MATERIAL AND METHOD:

We have reviewed the 32 cases, detected in a period of time between 1987 and 1991. Everyone have had coronary angiographic study in which obstructive coronary lesions were demonstrated.

The age of the population reported ranged between 39 to 56 years (43.7±4.8).

Assesment was made according to:
- Myocardial infarction   19 cases (54.9%)
- ST-T wave changes in ET   4 cases (12.5%)
- New Q or QS waves in EK   4 cases (12.5%)
- Exercice test for CVRF   3 cases (9.40%)
- Chest pain   2 cases (6.25%)

In each case incidence of smoking habits, hypercholesterolemia, hipertrigliceridemia, diabetes, hypertension, obesity and family history of CAD, has been studied as a risk factors.

Tobacco has been evaluated according to the number of daily cigarrettes and number of years of smoking habit.

Cholesterol levels have been calculated as a result of the mean values throughout the last 5 years. We consider high levels if elevated over 240 mg/dl, and cholesterol/HDL-cholesterol relationship were over 6.

Assesment of hypertrigliceridemia was made if levels of trigicerides were over 170 mg/dl.

Diabetes has been considered if glia mia levels were equal or superior to 120 mg/100 ml, at least in 3 samples.

Hypertension was assered if blood pressure values were equal or more than 150/95 mm Hg, at least in 3 measurements.

Obesity has been measured in percentage of weight excess in relation to the ideal weight. We have considered three categories: light overweight: between 10 and 15% ; moderate: between 15 and 20% , and severe: over 20%. Ideal weight has been calculated according to the following formula: Kg=(Height in cm-150)x0.75+50. Family history of CAD has been taken into account if parents, brothers and sisters have had a CAD before the age of 50.

RESULTS:

Prevalence of CVRF in each of the 32 cases are showed in Table I.

28(87.5%) out of 32 cases were heavy smoker (15 to 60 cigarretes/day mean 33.2±11.5 for a period of time between 15 and 37 years, mean 24.7±6.3).

Only 4 (12.5%) were non smokers, but 3 of them had levels of cholesterol higher than 270 mg/dl and the other have had an history of hypertension, diabetes, hypertrigliceridemia and obesity.

22 (68.5%) out of 32 have had plasma cholesterol levels over 240 mg/dl (284±26.4), with an total cholesterol/HDL-clolesterol ratio over 6 (7.86±0.9).

19 (86.3%) out of the 22 cases with hypercholesterolemia were smokers too, and 19 (67.8%) out of the total of 28 smokers had associated hypercholerterolemia.

Tobacco was the only CVRF known in 4 cases, while hypercholesterolemia as a single CVRF was found only in one case.

12 cases (37.5%), have had elevated levels of triglicerides (272.7±74.9 mg/dl), always associated with other CVRF: 10 were smokers and the two non smoker have had other 4 associated CVRF. 11 have had an elevated cholesterol, 10 out of these 11 had associated smoking habit, the one left have had diabetes, hypertension hypertrigliceridemia and obesity.

The only non smoker with normal cholesterol had diabetes, hypertension and obesity.

6 cases (18.8%) have been diagnosed of diabetes mellitus, one associated to smoking and obesity, and the other 5 associated with at least 3 CVRF.

We found in 9 cases (28.1%) mild hypertension. In all of them associated with smoking, cholesterol or more than other three CVRF associated.

12 (37.5%) presented obesity, 4 out of 12 light, 6 moderate and 2 severe. all of them presented several CVRF associated. In 6 cases we found a positive family history of CAD. All of them were smokers and 5 have had other associated CVRF.

DISCUSSION:

The evaluation of CVRF in aircrew members is very important to identify those who need additional testing trying to discover asymptomatic CAD (10). However, this procedure shows some mayor difficulties.

First of all, the dread to a dysqualification for flying duties lead, in some instances, to hide some data, like the number of cigarretes smoked. It is widely known some pilots, mostly civilians, follow strict diets during the days prior to the medical exam.

The farmacological control of hypertension, hyperglucemia, and hypercholesterolemia out of the aeromedical advise is something we should look after throughout the physical exam.

Most of the epidemiological studies show that high levels of cholesterol and hypertension increase the coronary risk, more than tobacco habit.

Our results reveled that tobacco is the major coronary risk factor. We think this is due to the high number of cigarretes smoked by the spanish aircrews (11), and to the fact, that our flyers very rarely keep levels of cholesterol or blood pressure out of the regulation limits without being either disqualified or reviewed in a short period of time. Limits for cholesterol and blood pressure for pilots are far away from the range studied in other populations (Cholesterol level of 330 mg/dl, and systolic blood pressure of 195 mm Hg in Framinghan study (12)).

CONCLUSIONS:

1.- All pilots with demonstrated CAD showed CVRF, most of them in multiple association.

2.- In spanish pilots, tobacco has been the major single CVRF. Hypercholesterolemia was the second one.

3.- Other CVRF besides tobacco and hypercholesterolemia seem of little relevance if they are not associated to them.

4.- It is necessary to stress among the flying comunity the importance of abandom tobacco habits, decrease the levels of cholesterol and the control of the other CVRF, to improve flying safety, reduce the negative impact on their general health and provide a better pilot's performance and proffessional career.

5.- To chek in routine aeromedical exams the tobacco's catabolites, glicosxilade hemoglobine or fructosamine and drugs related to the treatment of hypertension, obesity and dislipemia, could be useful tests for the aeromedical provider.

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TABLE I. PREVALENCE OF CVRF IN EACH OF THE 32 CASES

case	age	tobacco	CHOL	HT	DIAB	HTG	OBES	FAM.H
1	53	+	+			+	+	
2	41	+	+					+
3	53	+						
4	43	+	+			+	+	
5	53	+	+					+
6	54	+	+					
7	48	+	+	+	+	+	+	
8	56	+		+				
9	45	+	+					+
10	43		+					
11	41	+						
12	43	+	+			+		
13	48	+					+	+
14	47	+	+			+		
15	52	+	+			+	+	
16	51	+						
17	39	+				+		
18	45	+	+	+	+	+		
19	47	+	+					+
20	47	+			+		+	
21	41	+					+	+
22	55			+	+	+	+	
23	46	+	+			+		
24	48		+	+				
25	46	+	+	+	+		+	
26	44	+	+					
27	40	+						
28	54		+	+	+	+	+	
29	49	+	+				+	
30	50	+					+	
31	43	+	+	+		+		
32	50	+	+	+				

CVRF: Cardiovascular Risk Factor. CHOL: Hypercholesterolemia. HTG: Hypertrigliceridemia. HT: Hypertension. DIAB: Diabetes. OBES: Obesity. FAM. H.: Family history of Coronary Artery Disease.

Appendix

Table 1

CARDIOVASCULAR RISK FACTORS

NONINFLUENCEABLE	INFLUENCEABLE
-Sex	-Hipercholesterolemia (LDL-c increase)
-Age	-Low levels of HDL-c and other lipid metabolism abnormalities
-Family History	-Hypertension
	-Cigarrette smoking
	-Diabetes
	-Obesity
	-Sedentary behavior
	-Fibrinogen & Factor VII increase
	-Psychosocial factors

Table 2.
PARAMETERS ROUTINELY CHECKED AT THE PHYSICAL EXAMINATION OF THE MILITARY PILOTS.

	T-CHOL	HDL-CHOL	LDL-CHOL	VLDL-CHOL	APO	TRIGL	URIC	BG
BELGIUM	Y	Y	Y			Y	Y	Y
CANADA	Y	Y						Y
DENMARK	Y	Y	Y			Y		
FRANCE	Y	Y				Y	Y	Y
GERMANY	Y	Y			Y	Y	Y	Y
GREECE	Y					Y	Y	Y
ITALY	Y	Y				Y		Y
NETHERLANDS	Y	Y				Y		Y
NORWAY	Y	Y				Y		Y
PORTUGAL	Y	Y	Y	Y		Y	Y	Y
SPAIN	Y	(1)	(1)			Y	Y	Y
TURKEY	Y	Y	Y			Y	Y	Y
U. K.	Y					Y	Y	Y
US ARMY	Y	*						
USAF	Y	(1)						(2)
US NAVY	Y	Y						(2)

```
*      STARTING IN 1.992
(1)    WHEN TOTAL CHOLESTEROL ELEVATED
(2)    WHEN FAMILY HISTORY OF DIABETES
```

Y = yes

Table 3.
PERIODICITY OF THE BIOCHEMICAL CONTROLS

	T-CHOL	HDL-C	LDL-C	VLDL-C	TRYGL	URIC	BG
BELGIUM	4Y(1)	4Y(1)	4Y(1)		4Y (1)	4Y(1)	2Y
CANADA	4Y(1)						4Y(1)
DENMARK	5Y						
FRANCE	1Y	1Y			1Y	1Y	1Y
GERMANY	1Y	1Y			1Y	1Y	1Y
GREECE	1Y				1Y	1Y	1Y
ITALY	1Y	1Y			1Y		1Y
NETHERLANDS	1-2Y	1-2Y			1-2Y		1-2Y
NORWAY	1Y(2)	1Y(2)			1Y(2)		1Y(2)
PORTUGAL	1Y	1Y	1Y	1Y	1Y	1Y	1Y
SPAIN	3Y(3)	(3)	(3)	(3)	1Y	1Y	1Y
TURKEY	1Y	1Y	1Y		1Y	1Y	1Y
U. K.	6M(3)				6M(3)	6M(3)	6M(3)
US ARMY	1Y	1Y(4)					
USAF	2Y(5)						
US NAVY	3Y	3Y					

(1) EVERY 2 YEARS AFTER 40
(2) EVERY 6 MONTHS AFTER 40
(3) EVERY 1 YEAR AFTER 40 OR WHEN ELEVATED.
(4) STARTING 1.992
(5) CHANGING TO EVERY 3Y

Y = year

Table 4.
LIMIT VALUES FOR REJECTION. (mg/dl).APPLICANTS FOR PILOT TRAINING.

	T-CHOL	HDL-CHOL	T/HDL-C	TRIGL	URIC	BG
BELGIUM	250	<40		200	7	105
CANADA	90 % P.V.		6			GTT
DENMARK	300		6			
FRANCE	300			200		DM
GERMANY	200 (1)	<35		200	8	100
GREECE	240			140	7	115
ITALY	200 (2)	<40		175		110
NETHERLANDS	Normal values.					
NORWAY	Evaluated in combination with other risk factors					
PORTUGAL	Normal values			-		110
SPAIN	250	<35	6	200	7	115
TURKEY	300	<35	6	200	6	110
U. K.	Evaluated in combination with other parameters					
US ARMY	-	-	-	-	-	115
USAF	300	-	6			115
US NAVY	-	-	-	-	-	110

(1) 300 mg/dl for continuation

(2) 240 mg/dl "   "

Table 5.
POLICY WITH MILITARY PILOTS SHOWING ALTERATION OF THE
BIOCHEMICAL PARAMETERS AT THE PERIODICAL MEDICAL EXAMINATION

	CARBOHYDRATE	LIPIDS
BELGIUM	repeat test	control 1 month
CANADA	GTT. Hb Al C	treatment
DENMARK	treatment	treatment
FRANCE	diet.exer. advise	diet exer advise
GERMANY	further evaluat.	further evaluat.
GREECE	repeat test	repeat test
ITALY	Fructosamine. Hb Al C	repeat test
NETHERLANDS	further evaluat.	further evaluat.
NORWAY	Information	Information
PORTUGAL	further evaluat	further evaluat
SPAIN	GTT. Hb A1C	diet, ex, drugs
TURKEY	Repeat every 2 weeks	Repeat every 2 weeks
U. K.	further evaluat	further evaluat
US ARMY	GTT. HbA1C	diet, ex, drugs.
USAF	further evaluat.	diet, ex, drugs (non HPF)
US NAVY	further evaluat.	diet, ex, drugs (non HPF)

Table 6.
WHEN DIABETES MELLITUS IS DETECTED IN ONE EXPERI⁻NCED PILOT

	grounded	exer+diet	is permited to fly on sulphonil.	biguan.	insulin
BELGIUM	Y. Temp.	Y	Y(1)	Y(1)	N
CANADA		Y			
DENMARK		Y	N	N	N
FRANCE		Y	N	Y	N
GERMANY	Y	N	N	N	N
GREECE		Y			
ITALY		Y	Y	N	N
NETHERLANDS	Y Initial.	Y	N	N	N
NORWAY		Y	N	N	N
PORTUGAL		Y			
SPAIN		Y	N	N	N
TURKEY	Y	Y	N	N	N
U. K.	Y temp.	Y	Each case judged individually		
US ARMY		Y	N	N	N
USAF		Y	N	N	N
US NAVY		Y	N	N	N

(1) With weaver and after stabilization of the diabetes

Y = yes , N = no

Table 7.
NATIONS WITH ESTABLISHED MANAGEMENT PROGRAM FOR OBESITY

	YES	NO
BELGIUM	+	
CANADA	+	
DENMARK	+	
FRANCE		+
GERMANY	+	
GREECE	+	
ITALY		+
NETHERLANDS		+
NORWAY	+	
PORTUGAL		+
SPAIN		+
TURKEY		+
U. K.	+	
US ARMY	+	
USAF	+	
US NAVY	+	

Table 8
ESTIMATION OF THE PERCENTAGE OF NATO FLYING POPULATIONS THAT
DO EXERCISE REGULARLY.

BELGIUM	30 %
CANADA	75 %
DENMARK	50 %
FRANCE	95 %
GERMANY	65 %
GREECE	20 %
ITALY	40 %
NETHERLANDS	50 - 75 %
NORWAY	80 %
PORTUGAL	40 %
SPAIN	20 %
TURKEY	30 %
U. K.	NO DATA
US ARMY	100 %
USAF	80 %
US NAVY	100 %

13-8

Table 9.
ESTIMATION OF PERCENTAGE OF SMOKERS OF NATO FLYING POPULATIONS

BELGIUM	35 %
CANADA	25 %
DENMARK	50 %
FRANCE	28 %
GERMANY	30 %
GREECE	54 %
ITALY	40 %
NETHERLANDS	50 %
NORWAY	30 %
PORTUGAL	50 %
SPAIN	47 %
TURKEY	48 %
U. K.	NO DATA
US ARMY	20% in >40 y. 5% in <40 y.
USAF	10%
US NAVY	20-25% in >40 y. 5-10% in <40 y.

Table 10.
REGULATION OF ALCOHOL CONSUMPTION

	NO REGULATED	YES	HOURS PREFLIGHT
BELGIUM		+	12
CANADA		+	8
DENMARK		+	(1)
FRANCE		+	
GERMANY		+	12
GREECE		+	12
ITALY	(2)	*	
NETHERLANDS		+	10 (3)
NORWAY		+	10
PORTUGAL	+		
SPAIN	+		
TURKEY		+	12
U. K.		+	(1)
US ARMY		+	12 (4)
USAF		+	12
US NAVY		+	12 (5)

(1) depends on the amount of alcohol consumption.

(2) alcoholic beverages are not recommended 8 h. before fligth

(3) 24 h. after large intake

(4) 24 h. recommended

(5) between the last intake and the beginning of crew brief

Table 11

Dietary guidelines

1. Total calories supplied should be adequate to achieve and maintain the body weight close to the "ideal" value.

2. Decrease protein intake to approximately 15% of the total calories.

3. Carbohydrate intake should not be less than 50% of the total calories, with emphasis on complex carbohydrate and fiber, also limiting the amount of sugar.

4. Decrease the lipid intake to less than 30% of the total calories, the saturated fat to less than 10% and cholesterol to less than 300 mgs per day.

5. Decrease the sodium intake to less than 3 g. per day.

Table 12.
THE RESPONSABILITY OF ELABORATING THE MENUS AT THE AIR BASES.

	DIETITIAN	FLIGHT SURGEON	OTHER
BELGIUM	N	N	Y
CANADA	Y	N	N
DENMARK	N	N	Y
FRANCE	N	N	Y
GERMANY	N	Y	N
GREECE	N	Y	N
ITALY	N	Y	N
NEDERLANDS	N	N	Y
NORWAY	N	N	Y
PORTUGAL	Y	N	Y
SPAIN	N	N	Y
TURKEY	N	N	Y
U. K.	N	N	Y
US ARMY	Y	N	N
USAF	*	*	Y
US NAVY	*	*	Y

* OCCASIONALLY AT SOME AF BASES.

Y = yes , N = no

Table 13.
SELF-EVALUATION OF THE CATERING FACILITIES

	VERY UNSATISF.	UNSATISF.	NORMAL	SATISF.	VERY SATISFAC.
BELGIUM				+	
CANADA					+
DENMARK		+			
FRANCE					+
GERMANY				+	
GREECE				+	
ITALY			+		
NETHERLANDS			+		
NORWAY			+		
PORTUGAL		+			
SPAIN		+			
TURKEY			+		
U. K.		+	+		
US ARMY			+		
USAF		+			
US NAVY		+	+	+	

Results and Management of Pathological Lipoprotein Concentrations and other Cardiovascular Risk Factors in Military Pilots of the German Federal Armed Forces (a 4-year study)

Col MC Dr. Rödig, Erich

Head of Aviation Medicine Division,
Office of the Surgeon General GAF *)
Postfach 90 25 00 / 5 22
5000 Köln 90

SUMMARY:

As a result of research findings during the past years, the level and type of circulating lipoprotein concentrations have become a subject of focal interest. It is now well established that high cholesterol levels are related to the extent and severity of arteriosclerotic heart disease.
Before this background, the aeromedical physician is called upon to act now, considering the increased psychic and physical demands the new weapon systems will impose on the aviator.
In a 4-year survey the lipoprotein concentrations of German military pilots were examined under standardized conditions, the results being evaluated in a statistical program at the German Air Force Institute of Aviation Medicine. Additional risk factors influencing the cardiovascular system are also mentioned. Cholesterol levels > 220 mg/dl and HDL cholesterol < 35 mg/dl are considered as pathological. This is true in 52,4 % of German military pilots older than 41 years.
In 1992, of all pilots (N = 4563) examined, 37.2 % show cholesterol levels greater than 220 mg/dl, while 25.1 % have a tot. chol./HDL-chol. ratio > 6.0 . These results differ from those in the years before.
Therefore, besides dietary and physical fitness programs, a regime to reduce pathological lipoprotein concentrations will also be introduced.
It is mandatory from an aeromedical point of view that risk factors and disorders of the cardiovascular system be detected by medical flying fitness examination. This particularly applies to silent cardiac ischemia.

INTRODUCTION:

Under increased psycho-physical demands the pilot more and more becomes the limiting factor in the interface between man and machine at almost every level – aircraft design, operation and maintenance. Psycho-mental stress influenced by flying experience, mission type and subjective inflight events cause variations in the cardiovascular system. Moreover the circulatory system must adapt to changing physical and physiologic parameters as found in three-dimensional space. As additional factors influencing the cardiovascular system, vibrations, noise, climatic changes as well as cardiovasuclar reactions to spatial orientation have to be mentioned.
From an aeromedical point of view, there-

fore, it is mandatory that a trained and healthy cardiocirculatory system with adequate physiologic reactions to stress be considered an essential prerequisite for flying (1).

On the one hand, atherosclerotic cardiovascular disease is the leading cause of death and the most frequent cause of early invalidity in the Federal Republic of Germany. In 1987, cardiovascular disease had a share of 46 % as the leading cause of death in German men (2). On the other hand, it is now well established that high cholesterol levels are related to the extent and severity of atherosclerotic heart disease (3,4,5,6). Against this background, the aeromedical physician is called upon to act now.

In aviation cardiology, the problem of predicting which pilots are exposed to a high risk of heart attack is difficult because there are insufficient data available.

The question of secondary prevention in pilots arises only rarely, since those who have experienced episodes of coronary artery disease are seldom allowed to resume flying. Regularly, these patients give up contact to their aeromedical physician (7).

In addition to existing cardiovascular risk factors, age is the most substantive risk factor in the development of coronary heart disease. As the average age of German pilots is rather high - in comparison to other nations' aviators -, in 1988 the Internal Branch of the GAF Institute of Aviation Medicine started a prevention program with the aim to reduce the cardiovascular risk factors and to lower pathological lipoprotein levels, especially serum cholesterol. Similar efforts were made by the USAFSAM at Brooks AFB (8).

SUBJECTS AND METHODS:

The data used are derived from the GAF Institute of Aviation Medicine in Fürstenfeldbruck. At the Institute, aircrews of the Federal Armed Forces are examined up to the age of 41 every three years and annually thereafter, in accordance with the procedures set forth in the pertinent Joint Service Regulation (ZDv 46/6).

In addition to a neurological, opthalmological, ENT and dental medical examination, a thorough physical examination is performed. It routinely includes a rest ECG with prolonged recording. This is followed by a workload ECG according to

PWC 170, in which a cardiac frequency of 170 beats per minute must be equal to a minimum performance of 2.1 Watt per kilogram of body weight. Additional non-invasive cardiac measurements include a 2-D echocardiography and if necessary a 24-hour long-term ECG.

Apart from the standard haematologic, biochemical and urinary tests, the fasting lipid studies include cholesterol, HDL-chol., triglycerides, and if required Lp(a).

Starting in 1988, during routine aviation medicals the following cardiovascular risk factors were recorded:

- age
- arterial hypertension (BP > 160/95 mm Hg
  or
  > 240/120 mm
  Hg during exercise)
- overweight (Broca Index exceeding 100 %)
- lack of physical fitness (PWC 170 < 2.5
  W/kg of body weight)
- smoking (inhaling)
- triglycerides (if > 200 mg/dl)
- cholesterol (if > 220 mg/dl and
  HDL < 35 mg/dl)
- ratio tot. chol/HDL-chol. (if > 6.0)

The family medical history or any history of diabetes were not included in the evaluation.

Any indication of cardiovascular risk factors resulted in an informative interview with the respective person, outlining recommendations and discussing waver policy and the required controls by the unit flight surgeon.

The basic elements of lipid lowering diet consisted in a reduction of the intake of

- total nutritional fat
- saturated fatty acids
- total cholesterol to below 300 mg per
  day (9,10).

For any required enhancement of physical fitness an endurance training was recommended (minimum of 3 x 30 min exercise/week).

Reduction of overweight as well as stabilization of blood pressure were achieved under internal medicine regimen (11).
Any medication, however, had to be cleared by the GAF Institute of Aviation Medicine.

Starting in 1989, all data and findings collected during routine aviation medicals concerning blood lipids and cardiovascular risk factors were evaluated statistically by the ADP department of the Institute. From a set date, all data were traced back 3 years. Corresponding evaluations were carried out in 1990 and 1992.

The statistical analysis established three age groups:

- up to 30 years
- 31 to 41 years
- older than 41 years

Since all flying personnel older than 41 years receive their medical at the GAF Institute of Aviation Medicine annually, the latter group was examined 3 times between 1989 and 1992. This provided for a qualitative evaluation of the individuals' compliance with the initiated prevention program, as well as of their success in re-ducing their personal cardiovascular risk factors.

RESULTS:

Age:

Considering the fact that the risk of cardiovascular disease increases exponentially with age, the age structure of German air- crews is quite disadvantageous.
As of 13 April 1992, 4.563 pilots and WSOs were serving in the German Armed Forces with the following age distribution:

up to 30 years	26.1 %
31 to 41 years	44.1 %
over 41 years	29.8 %

The distribution of aircrews to the type of aircraft flown is as follows:

rotary wing a/c	44.2 %
fixed wing high performance a/c	45.9 %
fixed wing transport a/c	9.9 %

Matching age structure to airframe, 29.1 % of the jet pilots are in the age group up to 30 years, 48.7 % between 31 und 41 years and 22.2 % older than 41 years; 35.6 % of rotary wing pilots and 40 % of transport pilots are older than 41 years.

Comparing with recent years, there seems to be a slight improvement in the age structure of aircrews [Table 1].
This tendency should be enhanced further by the proposed reduction of personnel strength in the Armed Forces.

Arterial Hypertension:

There has been some distinct success in this field since 1989. Whilst in 1989, 14.5 % of the clientele showed hypertonic dysregulation of some degree, in 1992 only 7 % could be considered hypertonic under the criteria of the WHO (12).
Most impressive is the decrease in art. hypertension in the age group over 41 years from 21.3 % in 1989 to 10.4 % in 1992 [Table 2].

These results are even more encouraging when compared with the PROCAM Study (13) which states art. hypertension in 23.7 % of the studied population.

Overweight:

Not quite as promising are the results considering overweight (Broca Index > 100 %).
In neither age group any significant change could be monitored during the period of the study. Almost 30 % of pilots older than 41 years showed a Broca Index

of more than 100 % [Table 2]. A correla-
tion between obesity and coronary heart
disease (CHD) is to be expected with a

Body Mass Index (BMI) > 30:
BMI = body weight in kg/(height in m) 2
(14,15,16).

Lack of Training:

Insufficient physical exercise can be
considered a cardiovascular risk factor
(17,18,19).
In 1989, 19.7 % of the clientele showed
lack of training asdefined above while in
1992 this r imber was reduced to 12 %.

The most impressive enhancement occured in
the age group above 41 years where the
number of those found unfit went down from
15.7 % in 1989 to 7.4 % in 1992 [Table 2].

In accordance with other studies (20), the
results of 1989 correlate with the normal
distribution of German male adults. This
makes the reduction to 7.4 % even more
stunning.

As an additiona' result of the study,
during ECG registration (rest and
exercise) 6 % of all test persons showed
VEBs of some degree [Lown: I ~ IV a] and
in the age group over 41 this figure
increased to 10 %.

Inhalative Cigarette Smoking:

Within the total population studied no
change of smoking habits could be found
[Table 2]. However, the number of smokers
with cholesterol above 220 mg/dl continu-
ously decreased from 35.7 % of the total
group in 1989 to 32.5 % in 1992 the age
group 31 to 41 years with 7.3 % converted
smokers showing the most pronounced
difference.

These results, while not very promising on
their own, are still encouraging when com-
pared to other German studies listing 50 %
of 25 - 29 year-old males and 38 % of 40
to 60 year-old males as smokers.

Cholesterols/Triglycerides:

A reduction of pathological lipoprotein
levels could not be registered by this
study. In 1989, 36.4 % of all examinees
showed cholesterol levels > 220 mg/dl, and
in 1992 this figure had increased to
37.2 %.

In the age group older than 41 years,
cholesterol levels between 261 and 300
mg/dl were found in 14.5 % while 3.4 %
showed values of more than 300 mg/dl
[Table 3].

These absolute figures are definitely
better than those in comparable German
studies (Deutsche Herz-/Kreislauf-Präven-
tionsstudie 1984-86). This study shows
30 % of those older than 40 years to have
cholesterol levels of more than 260 mg/dl
while 9 % of the clientele had levels of
more than 300 mg/dl.

As an additional result of our study in
1989 as well as in 1991, 19.5 % of pilots
with cholesterol above 220 mg/dl and in
1992, 14.9 % of those pilots were also

found to have raised triglyceride values
(> 200 mg/dl) [Table 4].

Coming back to cholesterol, with a
threshold value of 200 mg/dl, an average
of 58 % of all test persons (75 % of those
older than 41 years) were in this category
[Table 5].
The same table indicates that, during the
period from 1990 to 1992, the quotient
tot. chol. over HDL-chol > 6.0 as one
relevant cardiovascular risk factor almost
doubles in the age group older than 41
years (13.4 % to 25.1 %).

Projected on the USAFSAM Risk Index
> 12000 in 1992, 33 % of this age group
demonstrated a high cardiovascular risk.
Astonishing are the results (chol > 220
mg/dl) in the age group older than 41
years projected to the aircraft flown. In
1992, 56.0 % of the transport pilots,
46.9 % of the helicopter pilots and only
33.7 % of the fighter pilots presented
increased cholesterol levels.

DISCUSSION:

As prevention is a vital cornerstone in
aviation medicine, a cardiovascular
disease screening program for aircrew
members was installed in 1988 at the GAF
Institute of Aviation Medicine for the
clarification of cardiovascular risk
factors and for the prevention and timely
detection of cardiovascular diseases.

Through education, individual counseling
and following the guidelines of the
European Atherosclerosis Society:
"Strategies for the Prevention of Coroi .ry
Heart Disease" (21), the influenceable
risk factors, notably hypertension, lack
of training, and cigarette smoking,
decreased significantly.

This is even more astonishing because the
values at the beginning of the study
already showed a lower level of path.
results as compared to the findings of
the normal distribution of German male
adults. The age group of pilots older than
41 years demonstrated a high readiness to
preserve their health. Physicians and
pilots are more and more convinced now of
the evidence that physical exercises and
changes of life style may prove to be of
benefit for flying fitness.

Unfortunately, as an important result of
that study, there was no significant
change in the laboratory findings of the
pathological lipoprotein levels. To our
pilots we have to emphasize the evidence
that, apart from watching the other risk
factors, dietary measures effectively
reduce the blood cholesterol levels. This
understanding is clearly demonstrated in
the group of the fighter pilots which
showed less increased cholesterol. Based
on the recommendations of the National
Cholesterol Education Program Expert
Panel, a model for the US Army aviators

predicts that at least 24.6 % of all aviators would require dietary or drug therapy (22,23). Based on cholesterol levels > 220 mg/dl, this is true for 36.5 % of German aviators.

Looking at the non-influenceable risk factors in German pilots (sex, age, family history) and at the ratio of tot. chol/HDL-chol and the triglyceride levels, a significant number of pilots are in a high or extremely high risk category for the development of coronary artery disease (CAD).

The results of the study and the overwhelming multitude of experimental, clinical and epidemiological data related to the "Lipid Hypothesis in Athero-sclerosis" (6) led to the development of a "Recommended Step Care of Hypercholes-terolemia" [Table 6] in accordance with the "Deutsche Nationale Cholesterin-Initiative" (2,9).

Pilots with cholesterol levels greater than 200 mg/dl are monitored and have to follow a step program to lower their high lipoprotein levels under close guidance by flight surgeons and the GAF Institute of Aviation Medicine. The target is to modify the cardiovascular risk factors in order to prevent the development of a cardio-vascular disease.

On the other hand a possible cardio-vascular disease has to be detected in its earliest stage.

The discussion goes on whether student pilots should be screened for Lp (a) (24,25,26) and LDL receptors to eliminate a high risk group in developing CAD.

Any drug therapy of hyperlipoproteinemia should be the last step in the aeromedical reflection on the problems of side-effects. In the majority of cases of cholesterolemia with values between 200 and 260 mg/dl, a reduction of the serum cholesterol level to normal physiological values can be achieved by correcting inadequate nutrition and modifying the risk factors.

This presentation is dedicated to **MajGen MC (ret.) Prof. Dr. H. Fuchs** on the occasion of his 75th birthday.

*) This research was also done during the assignment as Head
Internal Branch at the GAF Institute of Aviation Medicine;
Director: BrigGen MC Dr. F.J. Daumann

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Age Structure of Pilots and WSOs
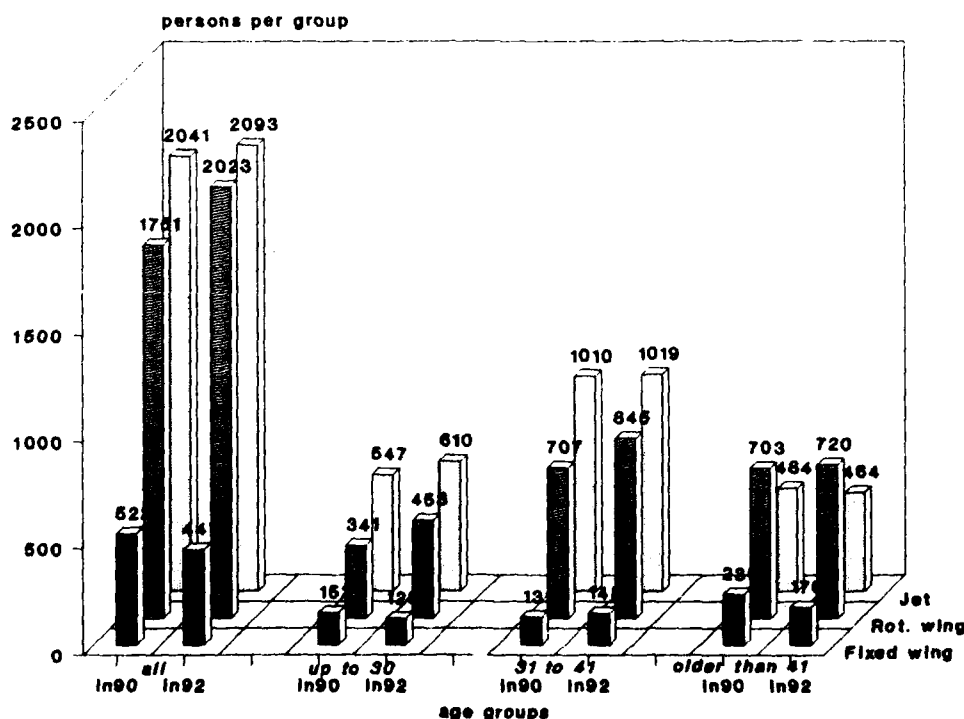
1990 N=4314, 1992 N=4563

Table 1

Pilots and WSOs
with Cardiovasc. Risk Factors
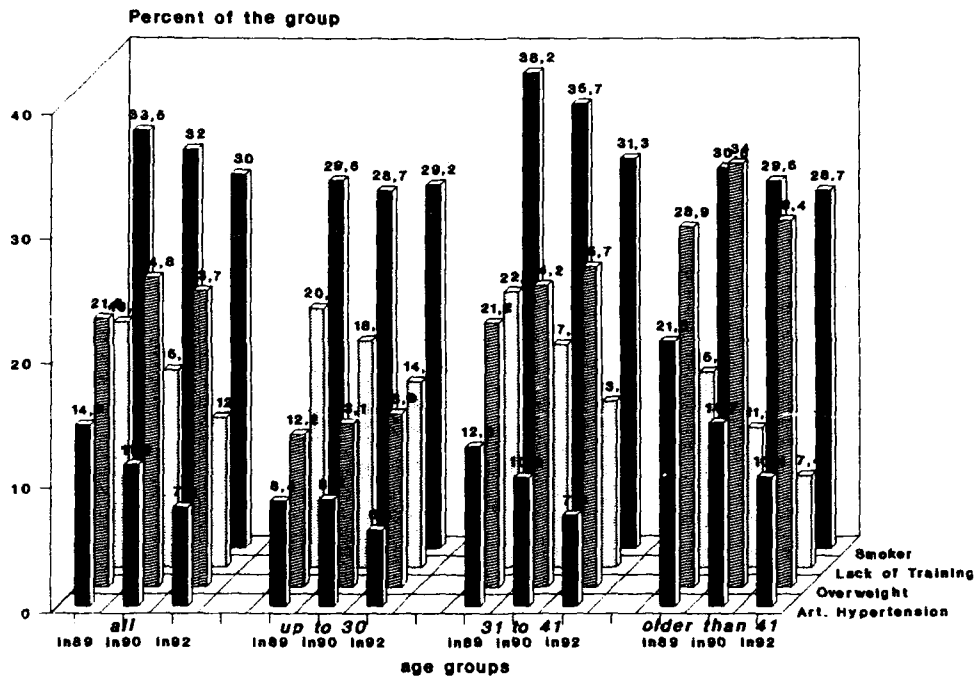
1989 N=4236, 1990 N=4314, 1992 N=4563

Table 2

Pilots and WSOs
with Cholesterol > 220 mg/dl

1989 N=4236, 1990 N=4314, 1992 N=4563

Table 3

Pilots and WSOs with Cholesterol
> 220 mg/dl

Persons per group

1600
1400
1200
1000
800
600
400
200
0

1261 1311 1470

260 26 22

163 176 260

601 631 614

617 604 606

Triglyc.<=200 mg/dl
Triglyc.>200 mg/dl

all
In89 In90 In92

up to 30
In89 In90 In92

31 to 41
In89 In90 In92

older than 41
In89 In90 In92

age groups
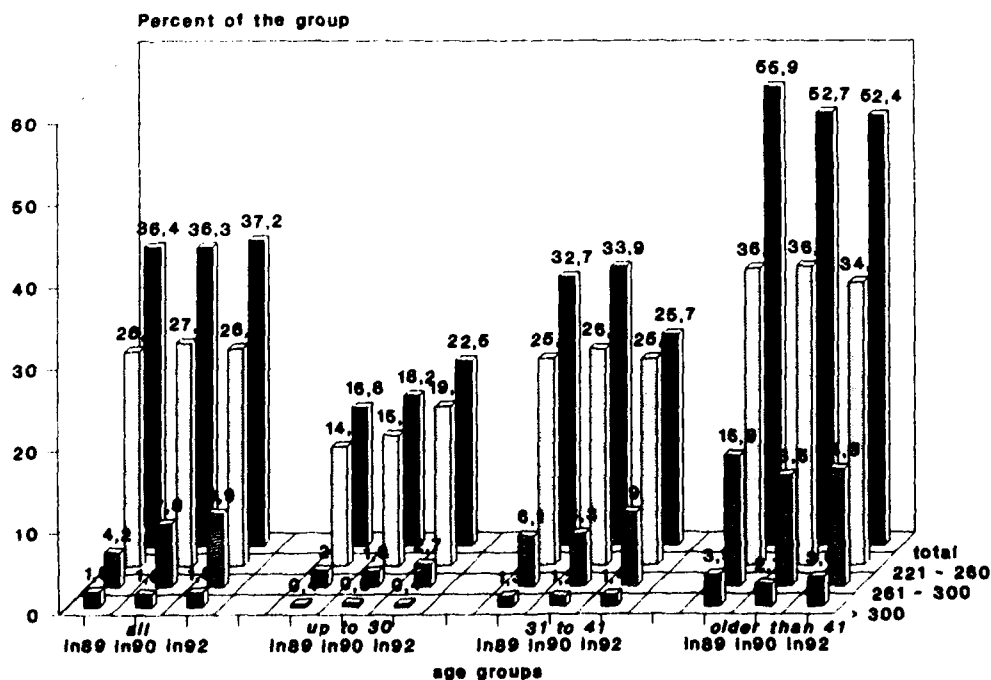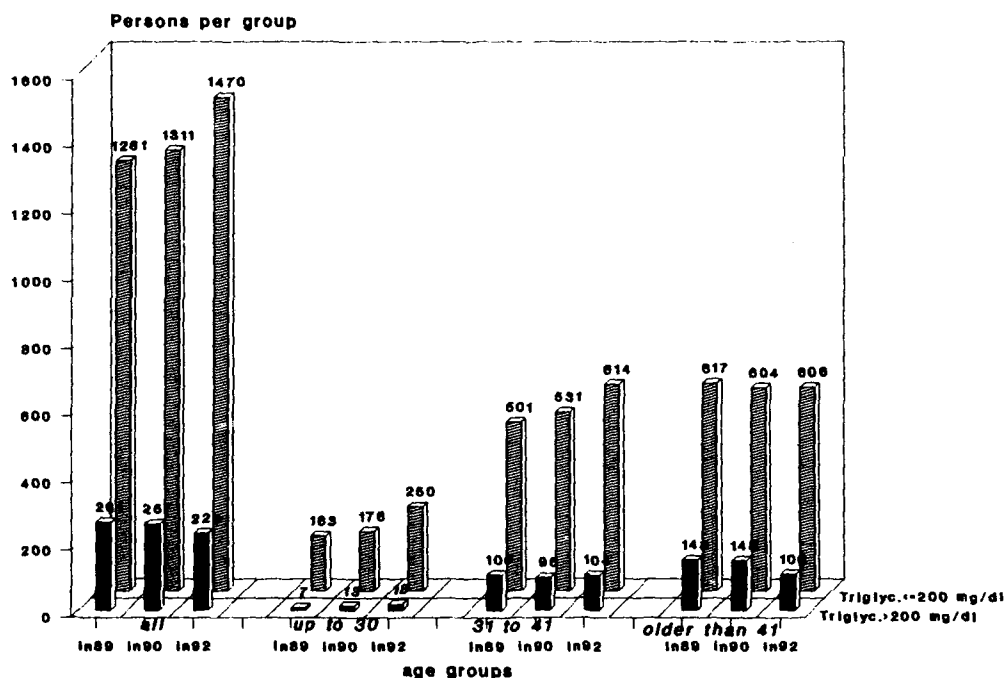
1989 N=4236, 1990 N=4314, 1992 N=4563

Table 4

Pilots and WSOs
with Hypercholesterolemia
Ratio = Tot. Cholesterol : HDL-Chol.

percent of the group

80
60
40
20
0

74,6 76,4

67,8 68,8

67,3 67,9

36,9 40,7

Chol > 200 mg/dl
5,0 - 6,9
> 6,9

all
In90 In92

up to 30
In90 In92

31 to 41
In90 In92

older than 41
In90 In92

age groups

1990 N=4314, 1992 N=4563

Table 5

```
no  ⇐  Cholesterol > 200 mg/dl  ⇒  yes
```

```
┌─────────────────────┐
│ Fitness for military│
│ flying duties, class II│
└─────────────────────┘
```

```
┌──────────────────┐        ┌──────────────────┐
│ Cholesterol      │        │ Cholesterol      │
│  > 200 mg/dl     │        │  > 250 mg/dl     │
│  < 250 mg/dl     │        │                  │
└──────────────────┘        └──────────────────┘
```

yes

```
┌──────────────────────────┐
│ If 2 or more of the      │
│ following factors apply: │
│ - cigarette smoking      │
│ - art. hypertension      │
│  - pos. family anamnesis │
│ - diabetes               │
│ - cardiolog. symptoms    │
│ - overweight             │
└──────────────────────────┘
```

```
┌─────────────────────┐
│ Fitness for military│   no  ⇐
│ flying duties, class II│
│ Nutrition counseling│
└─────────────────────┘
```

yes

```
┌────────────────────────────────────────────────┐
│ If the following applies:                        │
│ - LDL - Chol        >        155 mg/dl           │
│ - HDL - Chol        <         35 mg/dl           │
│ - triglycerides     >        200 mg/dl           │
│ - lipoprotein (a)   >     25 - 30 mg/dl          │
│ - total Chol/HDL    >          6,0               │
└────────────────────────────────────────────────┘
```
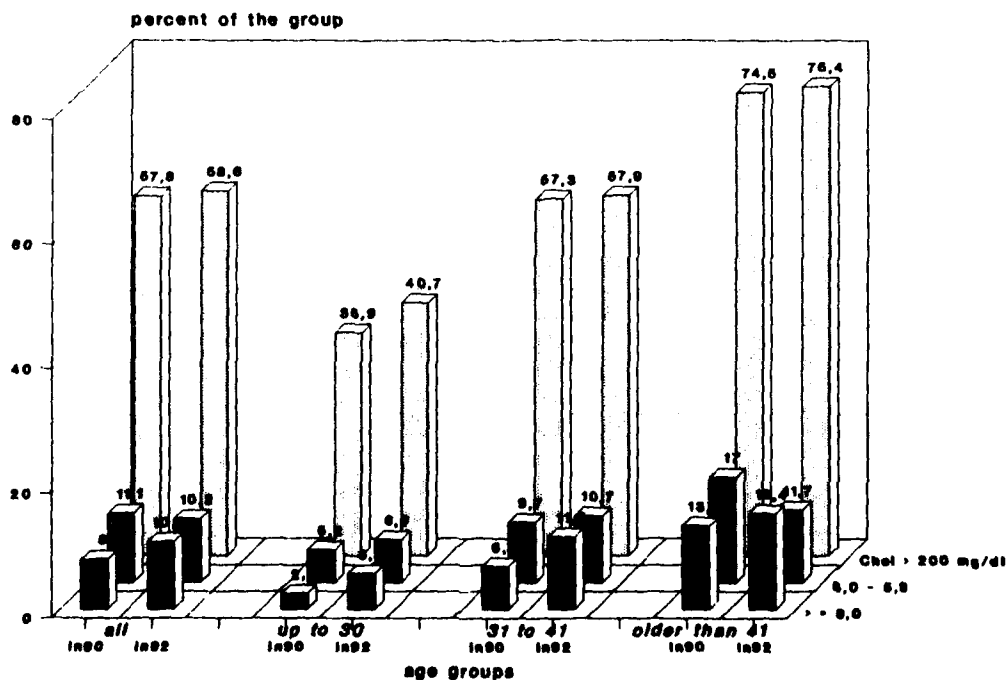
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┌──────────────────────────┐
│ Fitness for military     │   no  ⇐
│ flying duties, class II  │
│ lipid reducing diet      │
│ treatment of risk faktors│
│ guidance by              │
│ flight surgeon           │
└──────────────────────────┘
```

yes

```
┌──────────────────────────────────────────────┐
│ lipid reducing diet / medication               │
│ - treatment of accompanying risk factors       │
│ - assignment to a therapy group                │
│ - close guidance by flight surgeon             │
│ - fitness for military flying duties,          │
│   class II under the condition                 │
│ to report on schedule                          │
└──────────────────────────────────────────────┘
```

```
┌─────────────────────┐
│ Special Orders      │  Medication  ⇐
│ of the Surgeon      │
│ German Air Force    │
│ para. 658 ff.       │  required
└─────────────────────┘
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┌──────────────────────────────────────────────┐
│ Elimination of possible coronary               │
│    artery disease/artery occlusion disease     │
│ - Ergometric examin. after work                │
│ - 24 h ECG with anal. of ST segment            │
│ - two-dimensional echocardiography             │
│ - if applicable, szintigraphy/SPECT            │
│ - if applicable, vascular doppler examin.      │
│  /coronary angiography                         │
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┌──────────────────────────────┐
│ Duty not in flight/          │  if
│ temporary non fitness for    │
│ military flying duties       │  ⇐
│ intermediate medical         │
│ examination at the GAF       │
│ Institut of Aviation         │  suspected
│ Medicin according to         │
│ Joint Service Regulation     │
│ 46/6, para. 111              │
└──────────────────────────────┘
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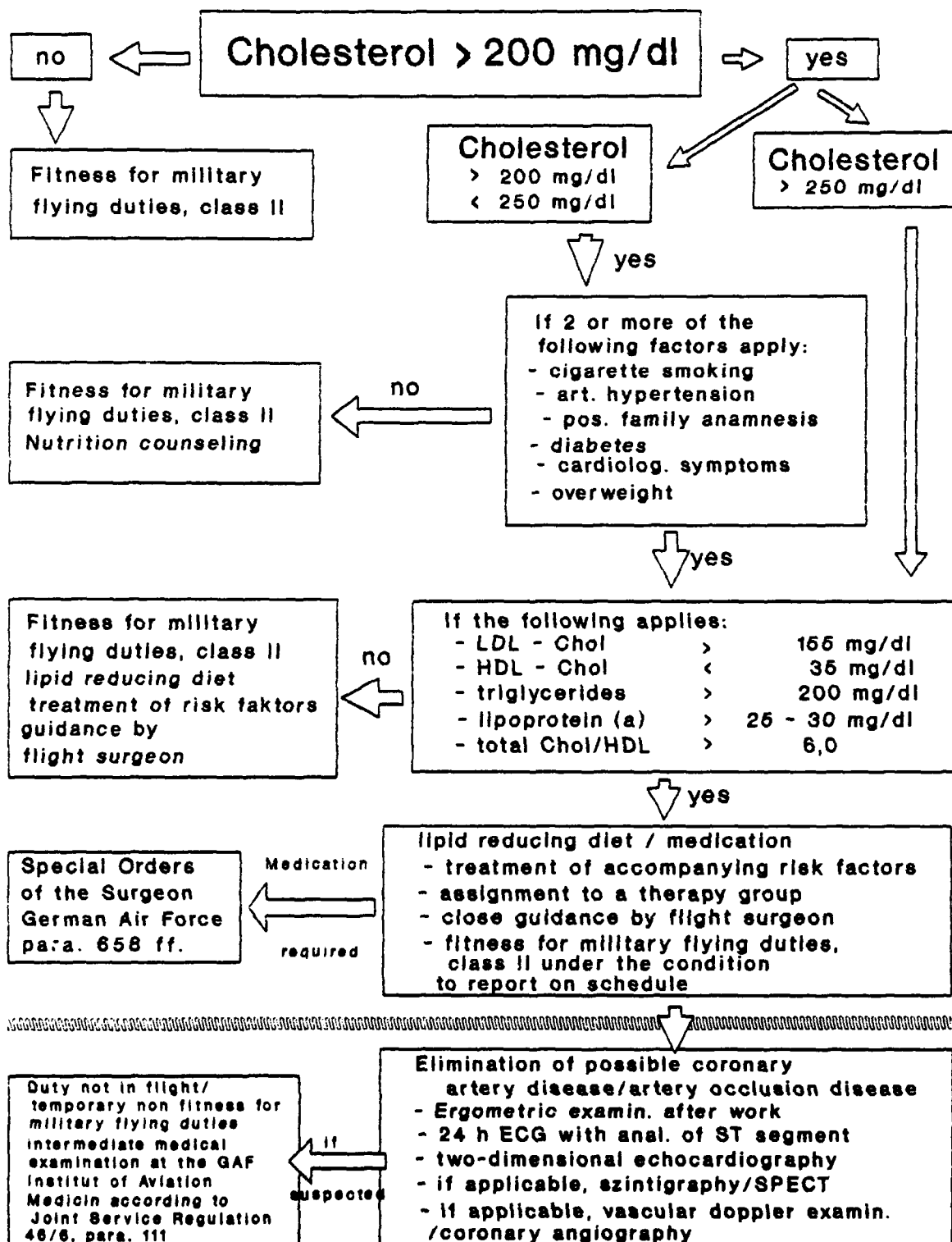
Table 6

NUTRITIONAL AND LIFESTYLE STATUS OF 50 PILOTS OF THE PoAF's

Maj. F.B. Oliveira, M.D.
Maj. N.L. Ribeiro, M.D.
Cap. S.R. Silveira, M.D.
Centro de Medicina Aeronautica
Paço do Lumiar
P. 1700 Lisboa
PORTUGAL

RESUME

A group of 50 pilots selected from a nom Academic pilot background, born between 1947-1960, had their body weight, smoking and drinking habits and blood pressure evaluated during a 10 years survey. 56% had Real Body Weight (RBW) > to the Ideal Body Weight (IBW), with a 28% of RBW > + 10Kg of the IBW.
Smoking habits were over 20cig./day in 36% and only 10% didn't smoke.
Declared alcoholic intake, over average comsumption, was admited in 14%, with 3 alcoholic psychiatric treatment and 1 admission to Hospital with Acute Alc. Hepatities. Blood pressure was over normal range in 12%. (A modified clinical and Laboratorial screening is being applied, since 1991.

INTRODUCTION

"PIL" is a group of pilots, in the Portuguese Air Force, that have not attended the Air Academy.
This is a group recruted from voluntiers or from the military service. This group started during the Portuguese Colonial War, to fullfil the lack of means in the pilot field.
Some of them were soldiers or NCO's, most mechanics, and some pilots, that were able to fly - would able to serve the task.
After the Revolution - in 1974 - most of these "PIL" returned to their squadrons, and were given the same tasks of all the others - except being in the same ranking "scheme" - and were always considered to have a different background.
Along the years, this "Population" was being noticed to have a major incidence of alcoholic problems, misbehavior and obesity.
Is among this group, from over 200 that we have chosen the 50 pilots born between 1947-1960 that were studied in this assay.
Their ages are from 45 to 32 years - and are still operational.

METHODS

SAMPLE: 50 pilots "PIL" born between 1947-1960.
10 years backup of Ideal Weight, Real Weight; Smoking and Drinking habits, Blood pressure, glicemia, Pathological data and Psychological evaluation including family ambience.
No other Laboratorial data could be gathered due to lack of information.

DEFINITIONS

- Ideal Weight = $\frac{H - 100 + 4 W}{2}$

(H- Height; W- Weight)
- Glicemia - mg/dl - 1990
- Blood pressure - laying, right arm

- Portuguese "normal/routine" diet
  * Proteins
  * H.C.
  * Fat
  * Fibers
- "Normal" alcohol intake:
  - 1 glass of wine at each meal
  ± 1 = 2 Beers/day

In the overall study of the 50 pilots we found:

- Concerning - Body Weight
RBW > IBW - 280 c. - 56%
RBW & IBW - 15 c. - 30%
RBW < IBW - 7 c. - 14%
RBW & IBW + 10 Kg - 14. - 28%

- Smoking Habits
0 cig/day - 5 - 10%
0 -10   - 13 - 26%
10-20   - 14 - 28%
+20   - 18 - 36%

- Alcoholic Bevarages
 - Declared abuse - 7 - 14%
 - Alcoholic psychiatric
   Treatment - 3 cases
 - 1 case of Acute Alcoholic Hepatities treated at the Air Force Hospital
 - Raised Blood pressure: 4 c.
 - Cardio - vascular pathology with treatment - 2

PSYCHOLOGICAL BACKGROUND

There are social and professional aspects of the "PIL" Population that should be evaluated on account of their potencial interference in their behavior. These aspects might lead us to a possibility of finding anxious and depressive patterns that are not clear, but that might be responsable for the nutricional excesses, lack of motivations, or low self-respect, and to a behavior caracterized by low motivation and sedentarism.
Some of these aspects are:
- Undervalue of the Professional status of this population in general, and by the other pilots's (PILAV - Academy Pilots)

- Low expectations of progressing in the ranking promotions, long periods in same rank

- Absence of familiar environment due to displacements on duty

- Contrast with civilian pilot's economical status.

CONCLUSIONS

A 50 pilot populations study revealed a high incidence of overweight pilots, maintained along

15-2

10 years of follow up.
A high incidence of smoker's and alcoholic intake was also registered.
The lack of motivation and the psychological background of these pilots, belonging to a specific area of the pilot group, we think are partially responsable for these results. Another important factor related to this lack of motivation is the contrast of their professional status with the Civilian Airline Pilots.
Since 1991 a wider Laboratory screening is being preformed to all Pilots, including total cholesterol, High and Low density Lipoproteins and Trigliceryds.

All pilots found to be overweight and with abnormal laboratorial tests were prescribed Low chaloric and Low Lipid diets.
The feed-back of this diet is of difficult control due to distance between the Aeromedical Center of the diferent Air Bases. Each Air Base recieve a writen repport of their medical examination, and tend to control this situation.
Apart from the Medical point of view and according to their Psychological evaluation, they should feel that an improvement in the social enviroment should start, with correction of the gap between other pilots from the PoAF and also with a better view of Civilian Airlines.

CORRELATION OF LIFE-STYLE AND DIETARY CONCOMITANTS OF GREEK PILOTS WITH SERUM ANALYTES

by

Ch. Daskalopoulos, J. Palermos, T. Zoga, A. Stavropoulos and K. Kyriakos
Hellenic Airforce General Hospital and Center of Aviation Medicine
P. Kanellopoulou
Messogion Av.
Athens 11525
Greece

SUMMARY.

We have correlated certain serum analytes (glucose,total cholesterol,HDL cholesterol, triglycerides, uric acid and γ-glutamyltransferase) with some lifestyle variables (dietary features, anthropometrics, physical exercise) in military (n = 157) and civilian (n = 157) male pilots in order to determine a possible relationship between these variables and their health status.

The subjects, randomly selected within a certain period, were currently active without any history of coronary heart disease or diabetes mellitus and were not receiving any medication.

In total, military pilots had statistically significant increased mean values of glucose, while a correlation of the mean values between groups with similar age showed that military pilots had increased cholesterol values and civilian pilots had increased triglycerides, LDL cholesterol and γ-GT values.

Both had an average body mass index (weight/height^2) of 25 and very few of them were following an effective physical exercise program toward lowering cholesterol level.

They preferred taking few (82.1%, 80.9% for military and civilian pilots respectively) but large meals (59.2%, 52.2% respectively). Concerning food composition, almost 30% of them were eating meals containing 38% or more fat, and 15% of them were eating meals with less than 44% carbohydrates of total daily caloric intake.

Finally, our data suggest that:
1) the concentration of certain blood analytes (glucose, cholesterol,)should be reduced 2) an effective regular aerobic exercise program should be followed 3) meals should be altered toward the pattern of "many and small" per day containing less fat and more carbohydrates.

1. INTRODUCTION

The relationship between health status and lifestyle variables (dietary features, body weight, cigarette smoking, alcohol consumption, physical activity) is apparent and consequently the regular screening of certain serum constituents (lipids, glucose, γ-GT) is the basic way of monitoring that status.

Specifically, the high blood lipids concentration and the pathogenesis of atherosclerosis as well the importance of lifestyle features on the cardiovascular diseases are well established (Ref 1,2).

Recently the National Cholesterol Education Program and the American Heart Association emphasized the significance of lowering the blood lipids concentration through the life-style modification (dietary changes, regular aerobic exercise, normalization of body weight and education program) (Ref 3).

Flying is a highly demanding profession, therefore the health care of military and civil aviation flying personnel is of high priority for primary medical prevention.

Having all the information we need from the serum variables, we can make the necessary interventions and recommendations concerning the lifestyle of pilots (Ref 4).

To get a better insight into our personnel's health status we correlated the lifestyle variables of military and civilian pilots with certain serum analytes and present our findings and proposals.

2. MATERIALS AND METHODS

2.1.subjects

The population under study consisted of 314 healthy Greek male pilots in active duty, serving in the Hellenic Air Force (n = 157) and in civilian airlines (n = 157) with similar, within group, socio-economic status. Their age distribution was, mean 32.7 and 41.0, median 32.0 and 41.0 respectively. For regression purposes all subjects (n = 179) between 25-40 years of age were subgrouped into two other groups, one of them serving in the Hellenic Air Force (a = 112) and the other serving in the civilian airlines (b = 67) with almost the same age distribution, mean 32.5, 32.6 and median 31.4, 32.0 respectively. They were randomly selected, within a certain period, among all those who were going through their periodic medical examination at the Hellenic Air Force Center of Aviation Medicine, in Athens. Individuals with any history of coronary heart disease, diabetes mellitus, high blood pressure or receiving any medication were excluded from the study.

From all participants' blood serum, that was drawn after overnight fasting, the following analytes were measured.

2.2. methods

Total cholesterol and triglyceride concentrations were measured enzymatically using a Trinder-type, and a GPO-PAP test without blanking method respectively, in a Technicon RA-1000 analyser.

Table 1. The results of the measurements (mean mg/dl ± SD, U/L for γ-GT) per analyte and age group.

		n	age	Chol	Trig	LDL	HDL	Glu	UrA	g-GT
(a)	pilots$_m$	157	32.7	224(50)	132(76)	156(47)	42(8)	102(14)*	5(1)	28(16)
	pilots$_c$	157	41	230(49)	147(83)	159(44)	42(8)	97(12)	5(1)	31(23)
(b)	pilots$_m$	112	32.5	231(51)**	135(74)	130(74)	41(9)	102(15)	5(1)	28(13)
	pilots$_c$	67	32.5	223(49)	145(78)**	153(46)**	42(8)	94(12)	5(1)	31(20)**

a = total groups, b = groups of 25-40 years age, pilots$_m$ = military pilots, pilots$_c$ = civilian pilots, *p<0.05 by Student's t-test, **p<0.05 by Spearman's rank correlation, Chol = cholesterol, Trig = triglycerides, LDL, HDL = LDL,HDL cholesterol, Glu = glucose, UrA = uric acid, γ-GT = Gama-glutamyltransferase.

HDL-cholesterol was determined by the CHOD-PAP method after precipitation of apolipoprotein B-containing lipoproteins with phosphotungstate in the presence of magnesium.
LDL-cholesterol was estimated using the Friedewald's formula LDLc= Chol-HDLc-(Trig/5) (Ref 5).
Glucose was measured enzymatically with an Hexocinase method in a Technicon RA-XT analyser.
Uric Acid concentration measured after an uricase catalysed oxidation of uric acid.
Gama-glutamyltransferase was measured by the Szasz method using glutamyl-p-nitroanilide as substrate.

2.3. quality control
For the quality control of our results we were participating in the Wellcome Clinical Chemistry Quality Assessment Program and we used control sera provided by the same manufacturer. The day to day variation as coefficient of variation was ranged between 3% and 7%.

2.4. life-style analysis
All participants completed a questionnaire concerning their personal life-style features as follows. The physical exercise level was determined on comparison to the cut-point of a 2 kilometers daily run or equivalent activity, that has proved effective toward lowering cholesterol level (Ref 6).
The food consuming behavior was graded according to the number, amount and composition of meals. Given the national life-style, two meals and a light breakfast or less per day, were considered to be few while more than these as many. An excess of 1200 calories per main meal was the definition of a large meal.
The study of food composition involved a basic quantitative estimation, in percentage form, of the food constituents (i.e. proteins, carbohydrates, lipids, vegetables, animal fat, vegetable oil, olive oil) per meal, as compared to a certain standard.
For the anthropometric study, we took in consideration the Body Mass Index (BMI) of the individuals, as the ratio of weight to the height squared (W/H²). For the body structural features we used the chest and pelvis (measured at the iliac crest levels) dimensions.

2.5 statistical analysis
The Student's paired t-test was used for comparison of the mean values between the groups and, the Pearson's Coefficient of Correlation and the Spearman's Coefficient of Correlation for the non parametric variables, were used for regression analysis.

RESULTS AND DISCUSSION

Table 1 shows the means of the analytes in the groups under study. There are large standard deviation values indicative of the wide distribution of analyte concentration values within the population. Taking in consideration that the subjects were healthy individuals and that these analytes vary mostly due to the food intake variation, it can be concluded that there are great differences in the subjects' eating habits.
Military pilots had statistically significant (p< 0.05) higher mean values of glucose, while civilian pilots had higher mean values of blood lipids concentration (cholesterol, triglycerides, LDL cholesterol), given the shift of the distribution of civilian pilots to older ages. By correlation of the mean values between groups of similar age, military pilots had higher (p<0.05) cholesterol values, while civilian pilots had higher (p<0.05) triglycerides, LDL cholesterol and γ-GT values.
Factors leading to higher or fluctuating levels of free fatty acids, like emotional stress, cigarette smoking, coffee drinking and partaking of a few large meals rather than continuous feeding, cause increased VLDL, triglycerides and cholesterol output from liver to circulation (Ref 7).
We found a tendency in our population to take few and large meals that could partially explain the difference between analytes. A further investigation on alcohol consumption, coffee drinking and cigarette smoking is currently taking place.
Considering the recommended cutpoints for blood lipids, beyond which is defined a high risk for coronary heart disease (cholesterol > 240 mg/dl, triglycerides > 250 mg/dl, LDL cholesterol > 160 mg/dl, HDL cholesterol < 35 mg/dl) and for glucose, uric acid and γ-GT the cutpoints of x+2SD, a significant percentage of the individuals under study had the measured analytes exceeding the set cutpoints (table 2) (Ref 3,8).

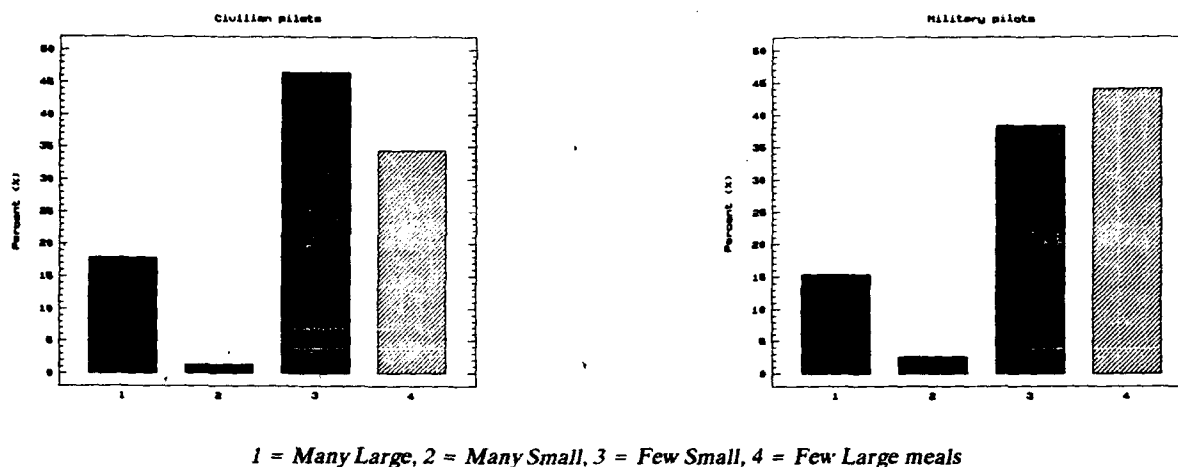**Figure 1. The daily eating pattern of population under stady.**

Civilian pilots   Military pilots

1 = Many Large, 2 = Many Small, 3 = Few Small, 4 = Few Large meals

Table 2. The percentage of individuals with serum analytes exceeding the "normal range set".

		Chol	Trig	LDL	HDL	Glu	UrA	γ-GT
(a)	pilots$_m$	39%	7%	25%	18%	2%	2%	5%
	pilots$_c$	41%	10%	46%	23%	2.5%	4.5%	2.5%
(b)	pilots$_m$	47%	7%	26%	20%	2%		2.5% 6%
	pilots$_c$	39%	9%	40%	22%	1.5%	3%	3%

For "normal range" see text, a = total groups, b = groups of 25-40 years age, pilots$_m$ = military pilots, pilots$_c$ = civilian pilots.

For γ-GT measurements, our results, (5% military pilots had above 60 I.U./L and 2.5% civilian pilots above 77 I.U./L), are close to those reported by others (Ref 9).

It is noteworthy that cholesterol and LDL cholesterol are frequently increased versus triglycerides, a finding that was additionally noticed in a parallel study in ground officers (data not shown). It is possibly, the high cholesterol intake that causes hyperlipidemia in our population.

Table 3. The composition of food intake in percentage.

	proteins (%)	carbohydrates (%)	fat (%)
ideal	10-20	50-60	30
our typical	18	44	38

	a	b	c	a	b	c	a	b	c
pilots$_m$	7	61	32	12	65	23	67	26	7
pilots$_c$	13	56	31	19	64	17	71	23	6

a = less than our typical, b = typical , c = more than our typical

The BMI (weight/height²) results were 25.3 and 25.5 for military and civilian pilots respectively (Ref 10).

With the cutpoint of physical activity set at the 2 kilometers daily run or the equivalent, very few subjects were found to follow an effective program toward lowering cholesterol (15% and 7% for military and civilian pilots respectively).

In figure 1 certain dietary habits of the population under study are shown. Both the examined groups (82.1%, 80.9% of military and civilian pilots respectively) preferred taking few meals. The majority of them (59.2% and 52.2% of military and civilian pilots respectively) were taking large meals. Specifically, the military pilots were eating few and large meals compared to the few and small meals of the civilian pilots.

Almost the same pattern was found in the same age distribution subgroups (data not shown). A small difference in the percentage (3.2%) of civilian pilots, who moved from taking few meals to many of them, was noticed.

For the estimation of the food intake composition we compared the composition of the subjects' food intake to that of a typical daily food intake that was representative of their socio-economic status and was found to be, proteins 18%, carbohydraters 44%, and fat 38%. For comparative purposes we report the ideally suggested range that is, proteins 10-20%, carbohydrates 50-60% and fat 30%.

From our data (table 3) we found that 33% and 29% of military and civilian pilots respectively eat meals containing 38% or more fat and, 12% and 19% of them respectively take food composed of less than 44% carbohydrates. Finally 7% and 13% military and civilian pilots were found to be eating meals that were made up of less than 18% proteins.

In conclusion, considering our data and the current bibliography (Ref 3,4,11) we would recommend the following lifestyle modifications that would improve the health status of the flying personnel and specifically their lipidemic profile.

1) Meals should be altered toward the pattern of many and small per day containing less fat and more carbohydrates. 2) The hidden fat should be avoided in the social, home and "meal at work" eating habits. 3) An effective regular aerobic exercise program should followed toward lower-

ing cholesterol level. 4) The primary prevention of cardiovascular diseases, through an education program, should be emphazised.

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The Lifestyle and Dietary Consumption Patterns of United States Air Force Aviators Within Air Training Command at Randolph Air Force Base, Texas.

Tammy J. Cook RD,MS[1]
Jonathan French PhD[2]
Beth Senne-Duff RD,PhD[3]

[1]Aeromedical Consultation Service
Armstrong Laboratory/Internal Medicine Branch
Brooks Air Force Base, Texas 78235 USA

[2]Armstrong Laboratory/Sustained Operations Branch
Brooks Air Force Base, Texas 78235 USA

[3]Coordinator Nutrition Program
Incarnate Word College
San Antonio, Texas 78209 USA

SUMMARY

A lifestyle survey was developed and distributed to two flying squadrons and to the rated officers of the 12th Flying Training Wing to examine lifestyle habits and dietary consumption patterns. Blood lipid profiles were gathered and classified using National Cholesterol Education Program (NCEP) guidelines. Eighty-two of 100 surveys were returned, and 75 completed 24-hour dietary recalls. As a group, these surveyed aviators consumed significantly less total fat, saturated fat, and dietary cholesterol than found in the typical American diet. Ninety-three percent were non-smokers and 16% did not drink alcohol. Twenty-eight percent described themselves as overweight by 6-10 pounds. Sixty-two percent exercised aerobically with 56% exercising three times a week or more. Monitoring total blood cholesterol level was important to 86% of respondents. Using NCEP guidelines, 36% of randomly sampled aviators were identified with LDL-cholesterol which may warrant dietary or lifestyle intervention. Future research efforts and a proposed approach for educational intervention are discussed for this population.

1 INTRODUCTION

Coronary artery disease (CAD) is a leading cause of nonaccidental mortality in the United States. The United States Air Force (USAF) emphasizes the role of elevated serum cholesterol as a risk factor in the development of CAD. Although the USAF promotes good health practices, incapacitation in flight from CAD is a direct threat to flying safety and mission completion (1). Therefore, all United States Air Force aviators receive annual medical evaluations and must meet established physical standards to remain on flying status. If cardiovascular disease is suspected, the aviator is referred for evaluation.

With the large investment in aircrew training and the personal interest of each aviator to continue the pursuit of their flying careers, it would be prudent to maintain all aviators on active flying status, provided flying safety is not jeopardized. Because medication usage in aviators may introduce a measure of risk to flying safety, non-pharmacologic methods of lowering blood cholesterol, (diet, exercise, and smoking cessation), generate much attention in the intervention of CAD in the aviator.

Recently Ornish et al. conducted a randomized, controlled, Lifestyle Heart Trial that suggested diet, stress management,

and exercise could lead to regression of coronary atherosclerosis (2). Even though results ar; controversial, this study foc .ses on controllable lifestyl< habits to reduce risk factors of heart disease.

Elevated serum cholesterol and its role in the development of CAD has been emphasized in medical screening and risk intervention. The National Heart, Lung, and Blood Institute (NHLBI) Coronary Primary Prevention Trial (CPPT) concluded that lowering blood cholesterol levels actually lowers the incidence of myocardial infarction (3).

Studies like the CPPT have led to the establishment of the National Cholesterol Education Program (NCEP), a nationwide effort within the United States to educate the public and reduce the prevalence of high blood cholesterol. Guidelines were outlined to define desirable blood cholesterol levels versus high blood cholesterol levels, to include recommended levels of low-density lipoprotein (LDL) as a chief indicator for cardiovascular risk (4,5).

The Adult Treatment Panel of the NCEP has specified coronary heart disease risk factors which include: male gender, family history of premature CAD (definite myocardial infarction or sudden death before age 55 in a parent or sibling), cigarette smoking (currently smokes more than 10 cigarettes per day), hypertension, low high-density lipoprotein (HDL) cholesterol concentration (HDL below 35 mg/dl confirmed by repeat measurement), diabetes mellitus, history of definite cerebrovascular or occlusive peripheral vascular disease, and obesity (>30% overweight)(4,5).

The NCEP defines blood lipid standards for adult screening. These include: desirable, total cholesterol <200 mg/dL; borderline, total cholesterol 200-239 mg/dL; high, total cholesterol >240 mg/dL. A high

total cholesterol should prompt a lipoprotein analysis to measure or estimate LDL-cholesterol. The LDL-cholesterol is a more specific determinant of CAD risk. An LDL-cholesterol of <130 mg/dL is desirable. Borderline and high risk are 130-159 mg/dL and >160 mg/dL, respectively. Total cholesterol and LDL-cholesterol level classifications are used as a guide for determining appropriate dietary and drug intervention (5).

Presently, USAF flying personnel have a lipid profile evaluated as part of the routine flight physical. Steinhauser and Stewart (6) reported a high incidence of elevated LDL-cholesterol in the flying population at Altus Air Force Base, Oklahoma, concluding that a significant number of aviators should receive some intervention. Additionally, Copp and Green (7) reported that 40% of the aircrew sampled at Tyndall Air Force Base, Florida should have medical follow-up according to the National Cholesterol Education Program guidelines. Because USAF aviators may resist pharmacologic intervention for hypercholesterolemia since it could affect their flying status (6), it would appear preferable to examine the lifestyle and dietary consumption patterns of aircrew, to develop intervention strategies using preventive medicine principles.

The purpose of this study was to focus on a target population of aviators in the USAF to examine lipid profiles and compare them with daily routines, dietary intake, body weight, smoking, and exercise habits, related to known risk factors for CAD.

2 METHODS

Study Design: A blind cross-sectional survey, including a 24-hour dietary recall, and retrospective medical record review were used to develop a descriptive model (8).

Population Description: The target

population of 127 personnel includes all Air Training Command (ATC) aviators assigned to the 559th and 560th Training Squadrons, as well as rated staff officers of the 12th Flying Training Wing, Randolph Air Force Base, Texas.

Research Instrument: A survey questionnaire was developed containing 84 questions on dietary consumption patterns, exercise routine, smoking habits, family history, alcohol intake, caffeine intake, vitamin usage, lipid profile knowledge, work schedule, and demographics. A 24-hour dietary recall was included with the lifestyle survey.

Data Collection: Approval to conduct this study was obtained from the commanders of the 12th Flying Training Wing and the 559th and 560th Flying Training Squadrons. The executive officers distributed 100 surveys to the personnel of each unit. Completion of the survey was voluntary, yet supported by the commanders. Forms were returned through the units' administrative staff or mailed directly to the author to be scanned and coded for analysis. The dietary recalls were cross-referenced with food frequency questions within the survey (9). Although completion of the survey was anonymous, individuals could obtain nutrient analysis results by including their names.

Seventy-four records were randomly selected from the roster of the target population. Height, weight, and the most recent lipid profiles were retrieved from selected medical records. A body mass index of 27.8 corresponding to obesity (20% over desirable weight) where treatment is recommended was used to screen height and weight. The NCEP lipid value guidelines were used to classify blood lipid levels. (4,5,10)

Data Analysis: Food intake data was coded and analyzed using a computer-assisted program based on United States Department of

Agriculture nutrient data (Nutritionist III, version 5.0, 1990, N-Squared Computing, Salem, Oregon). Descriptive statistics (means, standard deviation, ranges of scores, percentages) were computed for selected demographic/background variables, survey answers, lipid profiles, and dietary intake data.

3 RESULTS

Survey questionnaires (Men N=80/Women N=2) were completed, and dietary recalls (Men N=75/Women N=0) were returned.

Lipid data from retrospective record review: Objective data to include most recent blood lipid profiles are outlined in Table 1. Seventy-five medical records were selected. One record of a female aviator was excluded from the objective data analysis.

Table 1 Objective data and blood lipid profile results. (N=74)				
Variable	Mean	Std. Dev	Minimum	Maximum
Age	29.3	3.9	24.0	42.0
Cholesterol	183.7	32.3	124.0	268.0
HDL-Cholesterol	46.5	11.4	24.0	80.0
LDL-Cholesterol	117.7	28.6	62.0	206.0
Weight (pounds)	173.1	20.3	123.0	220.0
Height (inches)	70.9	2.4	65.0	75.5
Body Mass Index	24.3	2.1	19.7	28.2

Three individuals (4%) had confirmed total cholesterol greater than 240 mg/dL and 20 aviators (27%) had total cholesterol in the borderline high range of 200-239 mg/dL. Five records (7%) revealed LDL-cholesterol greater than 160 mg/dL and 21 of the records (29%) reviewed had LDL-cholesterol 130-159 mg/dL classified as borderline high risk. HDL-cholesterol <35 mg/dL was noted in 8 individuals (11%).

Each individual's height and weight were gathered to correspond with the blood lipid levels drawn during routine flight physicals. Five individuals (7%) were identified with a BMI of 27.8 and above, of which two dietary consults were written by the flight surgeon but dietary briefings were not accomplished.

Dietary Intake: Analyzed results of food frequency and dietary recalls are listed in Table 2.

Table 2 Twenty-four hour dietary recall results (N=75).				
Variable	Mean	Std. Dev	Minimum	Maximum
Total kcal	2210.5	738.5	475.0	4931.0
Fat (% of energy)	31.5	11.4	6.0	57.0
Protein (Gm)	91.0	40.5	6.3	254.0
Carbohydrates (Gm)	288.4	135.4	76.0	860.0
Total Fat (Gm)	77.3	39.1	6.0	218.0
Saturated Fat (Gm)	20.6	14.1	.1	74.8
Cholesterol (Mg)	193.4	140.3	0	805.0

kcal = kilocalories

Table 3 Nutrient composition for various diets			
Variable	Aviator Diet (N=75)	Current American	U.S. Dietary Goals
CHO (% of energy)	52	45	58
Protein (% of energy)	17	16	12
Fat (% of energy)	32	37	30
Sat Fat (% of energy)	8	13	10
Cholesterol (Mg/day)	193	435	250-300
CHO = Carbohydrate, Sat Fat = Saturated Fat			

Table 3 represents tabulated nutrient compositions for various diets using the current American diet, United States Dietary Goals and results from the aviator population within this study (11,12).

Survey Questionnaire: Thirty-three percent responded that outside normal work or daily responsibilities, exercise of 20 minutes or more which markedly increases breathing such as vigorous walking, cycling, running, or swimming was performed 3 times per week. Tables 4 and 5 list the type and duration of exercise for those 96% professing to exercise.

Table 4 Type of exercise (N=82)	
Type of exercise	Percent
Aerobic	62
Anaerobic	13
Recreational	12
Competitive Sports	9
No exercise	4

Table 5 Duration of exercise (N=82)	
Exercise duration	Percent
0-10 minutes	7
11-19 minutes	7
20-29 minutes	33
30-59 minutes	41
60 minutes or greater	12

When responding to the question *"How would you best describe your current weight?"* 32% of the aviators claimed *"ideal"*, 9% claimed to be underweight, 23% indicated they were overweight by five or less pounds, 28% reported overweight by 6-10 pounds, and 9% claimed to be overweight by 11-20 pounds. No one responded to being overweight by more than 21 pounds.

Nutrition knowledge was obtained through the media or literature (54%), flight surgeon (15%), family member (13%), friends or peers (7%), nutrition class in college (6%), and registered dietitian or diet therapist (3%).

Ninety percent of those surveyed claimed to be on temporary duty (TDY) or away from home less than 30 days per year. When responding to the question *"Do you ever skip meals due to your flying schedule?"*, a total of 87% said "YES, I SKIP MEALS BECAUSE OF MY FLYING SCHEDULE." Additionally, 10% claimed that they did skip meals but not because of the flying schedule. Other lifestyle questions include coffee consumption; 49% did not drink coffee, and 35% drank less than two cups per day. Of the 36% that claimed to take a vitamin supplement, the most prevalent rationales were "I DO NOT EAT BALANCED MEALS 100% OF THE TIME" (20%) and "It makes me feel better" (10%). Seven percent felt that a vitamin or mineral supplement is needed even with a balanced diet.

Ninety-seven percent did not smoke and 16% of those surveyed did

not drink alcoholic beverages. Of those who drank, 32% consumed 3-5 alcoholic beverages per week, 13% drank 6-11 drinks, and 4% drank more than 12 drinks per week. While on temporary duty (TDY), 33% drank an average of 3-5 beverages, 17% drank 6-11, and 12% drank more than 12 drinks per week. Thus, there is a slight increase of alcohol consumption while on TDY, especially when the duration of the TDY is less than a week.

Monitoring total blood cholesterol level was important to 86% of the respondents. Of the suggested reasons for monitoring, 52% claimed high cholesterol is a risk factor for coronary artery disease, 23% wanted a future job with a major airline, and 9% had family history for heart disease. Total blood cholesterol level was claimed to be known by 93% and 61% knew total cholesterol/HDL ratio. Fewer than 50% claimed to know their complete lipid profile.

4 DISCUSSION

This study showed that a significant percentage of aviators assigned to Randolph Air Force Base had risk factors for atherosclerotic disease. General lifestyle tendencies, dietary consumption patterns, and lipid profiles were examined for these selected aviators within Air Training Command. For this population, as identified by the NCEP, risk factors included: male gender, (2% surveyed were female), 9% with a family history of CAD, 3% were smokers, with 1% smoking more than 10 cigarettes per day, and 7% identified as 20% over ideal body weight. Eleven percent of the blood lipids reviewed had HDL-cholesterol <35 mg/dL which is classified as an independent risk factor.

The elevated total cholesterol (4% greater than 240 mg/dL and 27% from 200-239 mg/dL), was identified and documented by the flight surgeons during the flight physical. However, LDL-cholesterols were not routinely calculated. This explains why pilots claim to know total cholesterol, HDL-cholesterol,

and total cholesterol/HDL ratios but did not know LDL or triglycerides. With as many as 36% of aviators possibly requiring dietary and other lifestyle intervention based on a review of the LDL-cholesterol alone, it would appear that a significant number of aviators should be receiving dietary treatment as a start, directed to lower LDL-cholesterol to levels below the cutpoints for initiating therapy, i.e., to below 160 mg/dL, or to below 130 mg/dL if definite coronary heart disease (CHD) or two other CHD risk factors are present (5).

As reflected in Table 3, nutrient intakes assessed by the 24-hour dietary recalls were listed in comparison to the current American diet and U.S. Dietary Guidelines for Americans. Compared to the average American diet these aviators consume less total fat, saturated fat and and total dietary cholesterol, mirroring dietary recommendations for the prevention of heart disease. However, an evaluation using U.S. Dietary Guidelines for Americans indicate these aviators consume slightly higher protein and total fat than is recommended, and lower amounts of carbohydrate. This group may benefit from increase consumption of complex carbohydrates. Further investigation utilizing a directed 24-hour recall administered by trained personnel, would allow for more accurate information to be applied to each individual. The author utilized participant recall only where accuracy solely depended on conscientiousness of the subject and ability to estimate quantities. Therefore, results better represent the group, not individuals requiring dietary intervention (9).

As noted in this study, unit flight surgeons were quick to recognize and intervene when aviators were identified with hypercholesterolemia. The unit flight surgeons appropriately developed and implemented treatment which utilized existing weight management programs (AFR 35-11) and dietary counseling services as

available. The unit flight surgeon played an active role in briefing the squadron as reflected by the fact that 15% of the aviators cite them as their primary source of knowledge regarding nutrition. The survey also noted that only 3% of all aviators received nutritional information from a registered dietitian or diet therapy specialist. Nutrition education therefore, is an area where dietitians and certified diet therapy specialists could be incorporated into a team, freeing the unit flight surgeons for other duties.

5 CONCLUSION

This study demonstrated that a significant number of Air Training Command aviators assigned to Randolph Air Force Base would benefit from nutrition intervention and lifestyle modification. With routine physicals and comprehensive monitoring in place, nutritional intervention and lifestyle modification could be implemented. Military registered dietitians and qualified Air Force diet therapy specialists are available in the local area for dietary counseling and are underutilized by this population.

Dietitians should take a proactive approach in the development of nutritional educational materials, command tailored, to be used within the flying squadrons, by existing flight surgeons and health promotion personnel. Positive lifestyle habits associated with the prevention of CAD, could be presented at the squadron level during mandatory safety meetings, base health fairs, and Commander's Calls. Utilizing multimedia, such as handouts and videos tailored to the aviator, may prove beneficial since 54% of this group obtained overall nutritional knowledge from media and literature.

Those in this study identified with high risk factors may require initiation of aggressive medical follow-up, as outlined in the NCEP guidelines. One suggestion may be

a realignment of priorities for existing medical personnel, who are qualified to provide nutritional and lifestyle intervention. All aviators should be encouraged to seek individual dietary treatment at local bases.

There is a high interest within these aviators in maintaining recommended blood lipid levels for medical, health, and job security reasons. These recognized motivators should be identified by flight surgeons, dietitians, diet therapy specialists, and local health promotion committees, and be reflected in the marketing and dissemination of nutrition intervention strategies.

This was a study of Air Training Command aviators assigned to Randolph Air Force Base, Texas. These results may not apply to aviators assigned to other commands, performing different missions. However, future studies should be directed at identifying effective nutritional intervention methods and lifestyle modifications that can be implemented thoughout the Air Force.

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OBJETIVE IMPROVEMENTS OBTAINED BY CONTROL OF DIET AND PHYSICAL TRAINING IN SPANISH AIR FORCE FIGHTER PILOTS

Lt.Col. José L. García Alcón MD.PhD.
Flight Surgeon. Chief of Aviation Medicine.
Talavera AFB. SAF.
Mª del Rosario Durán Tejeda. MD.
Juan M. Moreno Vázquez. MD.PhD.
Medicine Faculty. Physiology Dept.
Extremadura University. SPAIN

SUMMARY.-

The present study aimed at investigating the effect of diet and sport practice in a homogeneous – age, sex and environmental stress – group of pilots (n=90), in order to evaluate the impact of diet and sport practice on body weight and plasma lipid levels. The dietary intake, was a typical mediterranean diet, (55-60 % carbohydrates, 25 % lipids and 15-20 % proteins and 3000 Kcal daily). It was controlled by the Flight Surgeon Office. The sport practice was grounded in a physical training program for pilots, directed by the Physical Training Officer. A marked difference in all studied lipid parameters was found between groups with free diet versus controlled diet. A difference in HDL-C levels and TC/HDL-C ratio was found between groups with regular physical training versus free sport practice.

INTRODUCTION.-

Coronary heart disease is the major cause of mortality in industrialized countries, and atherosclerosis is the pathological process contributing to the majority of these deaths (9). Some risk factors of cardiovascular disease – age, sex, serum lipids, blood pressure, cigarette smoking, obesity, and sedentary life/work style – are not encountered in some cases of coronary heart disease. Other contributing factors have been sought, among which is emotional stress (3). Mental stress has been widely implicated in the aetiology of hypertension and atherosclerosis (7).

It is well know plasma lipid levels are influenced by age, sex, body weight, dietary intake, sports practice and environmental stress. The present study aimed to research the effect of diet and sport practice in an homogeneous – age, sex, body weight and environmental stress – group of pilots (n=90), belonging to the Spanish Air Force, in order to evaluate the impact of diet and sport practice on body weight, body mass index (BMI) and plasma lipid levels, in three different experimental situations.

MATERIAL AND METHODS.-

This study has been performed on a group of young pilots belonging to the SAF (n=90) and a Control Group made up of non smoking healthy males (n=30) – medical students – of the same age ranging (See Table I).

Experimental subjects were officers assigned at Talavera Air Force Base, to perform the "Fight and Attack" course, for one year. This pilots proceed from the Air Force Academy, where they have spent the last four years, being submitted at the same dietary intake and methodical physical training.

This study has been developed for three consecutive years, in three consecutive classes. During the first year, diet and sport practice were free according personal preferences (Group A). In the second year, dietary intake was controlled following a protocol forward sketched, but pilots remaining with freedom to sport practice (Group B).

Finally, in the third year, pilots were submitted at controlled dietary intake and physical training program (Group C), (see Table II) This program will be explained later.

After an overnight fasting, blood was obtained from antecubital vein in chilled tubes containing 10 % EDTA and centrifuged at 2000 rpm during 10 minutes. The plasm was stored at 20 negative Celsius degrees until arranged. The sample assay was performed three times (T_1=Start; T_2=Middle; T_3=End of the course), this stages were separated each one by five months.

Lipids determinations – Total Cholesterol (TC); Hight Density Lipoprotein Cholesterol (HDL-C); Low Density Lipoprotein Cholesterol (LDL-C); Triglycerides (TG) and ratio TC/HDL-C – were developed according to standard techniques by spectrophotometry using Boehringer Mannheim GmbH kits.

The results are expressed on Mean±SD. Statistical analysis of paired or non paired data was performed using The One Way MANOVA test, the Mann-Whitney, Student's T and Cochram Tests.

Dietary protocol.-

The programmed dietary intake was a typical "mediterranean diet", characterized by following ratio: 55 - 60 % carbohydrates, 25 % lipids and 15 - 20 % proteins. The caloric amount was 3000 Kcal daily, split into three main and two "minor" intakes, according to personal preferences and local habits.

The carbohydrates contribution was composed of a variable mixture of vegetables, feculae, cereals, italian paste, bread, fruits, milk and its derivatives and cakes. The ratio between fast and slow absorption carbohydrates was 5 % to 95 %. The lipids contribution was composed of a seasonal variable proportion, of animal and vegetable fats. The proteins contribution was composed of an equilibrate mixture of meat of veal, pork, lamb, poultry and sea-food. This protocol was controlled by the Flight Surgeon Office.

Physical training program.-

The aim of this program is pilots maintain the fitness obtained in Air Force Academy for its professional life. In addition, to fight pilots es very important to improve the strength and endurance conditions of the muscle groups involved in protection of G-load. This program gives preferential treatment to improve anaerobic endurance, but it do not forget the aerobic endurance improvement.

The program is composed by three weekly sessions, lasting one hour each one. The training sessions, are alternatively spent to improve strength or endurance.

The training session starts with ten minutes of stretching, after that, forty minutes of exercises with weights by isotonic method and ending with another ten minutes of stretching. See Table II

In addition, one time per week, another session is performed. This session is characterized by an aerobic exercise, as running, swimming, cycling according to personal preferences. This program, was controlled by the Physical Training Officer.

RESULTS.-

Table I shows anthropometric data evolution. No significantly statistical differences were found not among different groups studied nor different phases either.

Table III shows lipid parameters evolution in group with free diet and free sport practice (Group A). A significantly ($p<0.001$) progressive increase of the Total Cholesterol, the LDL-Cholesterol and Triglyceride levels and, at the third phase, a significantly ($p<0.01$), decrease in the HDL-Cholesterol. Consequently, the TC/HDL-Cholesterol ratio was significantly ($p<0.001$) increasing progressively.

Table IV shows lipid parameters evolution in group with controlled diet and free sport practice (Group B). No significantly changes in lipid levels was found in this group, except a similar decrease in the HDL-Cholesterol in the third phase, as was observed in group A. Likewise, the TC/HDL-Cholesterol ratio was significantly ($p<0.001$) increasing progressively.

Table V shows the results obtained in the last group when we controlled both, the diet and sport practice. The Total Cholesterol, LDL-Cholesterol and Triglyceride levels, showed a similar evolution that in group B. The most important finding in this group, was the stopping of the grim HDL-Cholesterol decrease observed at the third phase in prior groups, but this change was not statistical significantly.

The main results obtained in this study are summarized in Figure 1.

DISCUSSION.-

Most authors (1,9,10) agree that individual variations in concentrations of serum cholesterol, lipoproteins and apolipoproteins are influenced by age, sex and body weight. Other authors (2,5,6,8,9,11) point out changes in catecholamine and lipoproteins occurring in association with environmental stress (psychological and/or physiological). Finally, some authors (3,8) report de crucial role of dietary intake - with particular attention to caffeine, alcohol, fat and cholesterol - on serum cholesterol and lipoprotein levels. In this study, the individual variations influenced by age, sex and environmental stress, has been obviated. Thus, the differences observed in serum lipids among the studied groups were fundamentally related to dietary intake variations and physical exercises

In T_1, the three studied groups - coming from Air Force Academy were they lead a similar kind of diet and a meticulous daily physical training for four years, showed model lipid values versus data measured in Control Group, characterized by TC, LDL-C, TG levels and TC/HDL-C ratio lower and HDL-C higher than control group ($p<0.01$).

In the Group A, the TC, LDL-C and TG levels and the TC/HDL-C ratio showed a progressive increase from T_1 through T_2 to T_3 reaching the Control Group values. In the same way the HDL-C level showed a progressive decrease, being at T_3 lower than Control Group. On the other hand in the Groups B and C, with controlled diet, the TC, LDL-C and TG

levels kept going the same levels that at the study beginning, being all the time these data significant statistically (p<0.01). In the Groups A and B - without physical training program - the HDL-C levels evolution were similar. These results agree with authors before mentioned (3,8) since the lipid level variations that have been observed for us, could be explained by the different dietary intake followed by Groups A and B.

In the Group C, which had a physical training program, the HDL-C levels do not showed the important decrease observed in Groups A and B. A slightly decrease of this parameter was only observed, but no significant statistically difference was found among Control Group, Groups A and B - without physical training program - and Group C. Consequently, the TC/HDL-C ratio do not showed an important increase as was observed in Groups A and B, remaining below that Control Group level. Some authors (4, 7) report sustained physical training produces a HDL-C level increase - by a lipoprotein-lipase activity increase - and consequently the loss of physical training, could cause a decrease on that parameter. Mena (7) reports a progressive lipoprotein-lipase activity increase in professional cyclist from the beginning to the end of the training season and from before to the end of cycle races which length was 900 Km in one week. In addition, Sapolsky (9) reports elevated levels of environmental stress could cause lower HDL-C concentrations.

Our results characterized by a important decrease of HDL-C levels in subjects who drop the daily sport practice and they are submitted to increase of environmental stress (progressively difficult flight missions), could be explained by both hypothesis, or even another unknown reasons. Studies in order to make clear the possible factors involved in the HDL-C variations are necessary.

CONCLUSIONS.-

The following conclusions were drawn from the present study:
First: An important and significant statistically differences in studied lipid parameters was found between sedentary controls and subjects with methodic physical exercises and controlled dietary intake - the three group coming from the Air Force Academy.
Second: Group A with free diet during the study, showed a progressive approaching to sedentary controls.
Third: Groups with controlled dietary intake (B and C) do not showed variations in lipid parameters levels, excepting HDL-C values.
Fourth: Conclusions about the behaviour of the HDL-C levels depending of physical exercises and environmental stress is not possible extracting from our study.

TABLE I. ANTHROPOMETRIC DATA EVOLUTION (X±SD)

	Group A		Group B		Group C		Control
	Start	End	Start	End	Start	End	
AGE	21.68 ±1.14		21.73 ±1.02		21.40 ±1.12		24.12 ±4.98
Weight *	70.28 ±6.90	72.95 ±7.20	71.30 ±6.34	72.00 +6.40	70.87 ±5.92	70.40 ±5.39	76.45 ±11.20
Heigth **	176.50 ±7.12		176.5 ±7.33		175.82 ±6.81		176.32 ±7.42
BMI ***	22.69 ±7.07	23.42 ±7.12	22.68 ±7.13	23.31 ±7.28	23.07 ±7.02	23.02 ±7.00	25.42 ±6.11
n	30		30		30		30

```
 *     = Kg.
 **    = cm.
 ***   = Body Mass Index
```

TABLE II PHYSICAL TRAINING PROGRAM

Heating − (Stretching) 5-10 minutes		
Exercise	Sets Strength/Endurance	Repetitions Strength/Endurance
1.- Leg press	4/3	5/10
2.- Bank press	4/3	5/10
3.- Tractions	3/3	5/10
4.- Military press	3/3	8/16
5.- Arm curly	3/3	6/12
6.- Abdominals	2/2	15/20
7.- Neck	3/3	6/12
Relaxation (Stretching) 5-10 minutes		

TABLE III LIPID PARAMETERS EVOLUTION IN GROUP A (X±SD)

Paramet	Control Grp	Start	Middle	End
TC	165.08±28.87	123.79±28.87	144.00±30.08	160.79±38.89
HDL-C	37.92±9.27	40.75±11.15	48.38±10.52	31.96±11.80
LDL-C	109.12±31.30	67.58±23.97	79.54±27.15	109.00±37.26
TG	94.86±39.46	60.79±32.10	79.96±26.96	101.54±44.92
TC/HDL-C	4.60±1.38	3.28±0.90	3.01±0.82	5.37±2.51

Units: mg/dl

TABLE IV LIPID PARAMETERS EVOLUTION IN GROUP B (X±SD)

Paramet	Control Grp	Start	Middle	End
TC	165.08±28.87	132.45±31.42	138.35±35.53	122.55±36.54
HDL-C	37.92±9.27	45.75±09.45	43.15±08.08	23.10±05.77
LDL-C	109.12±31.30	76.25±29.64	80.70±29.52	92.05±39.73
TG	94.86±39.46	54.70±40.78	72.85±62.62	60.55±29.79
TC/HDL-C	4.60±1.38	2.99±0.87	3.29±1.05	5.60±1.93

Units: mg/dl

TABLE V LIPID PARAMETERS EVOLUTION IN GROUP C (X±SD)

Paramet	Control Grp	Start	Middle	End
TC	165.08±28.87	130.62±30.72	136.45±31.48	128.35±34.74
HDL-C	37.92±9.27	43.66±10.12	41.12±10.12	34.18±06.87
LDL-C	109.12±31.30	78.75±28.72	82.78±27.52	82.05±37.72
TG	94.86±39.46	56.68±37.56	70.64±62.32	58.36±27.38
TC/HDL-C	4.60±1.38	2.89±0.78	3.27±1.03	3.75±0.83

Units: mg/dl

Total Cholesterol

mg/dl

Control

| | T1 | T2 | T3 |

— Group A   + Group B   —*— Group C

GA & MV

HDL-Cholesterol

mg/dl

Control

| | T1 | T2 | T3 |

— Group A   + Group B   —*— Group C

GA & MV

TG

mg/dl

Control

| | T1 | T2 | T3 |

— Group A   + Group B   —*— Group C

GA & MV

TC/HDL-C

Control

| | T1 | T2 | T3 |

— Group A   + Group B   —*— Group C

GA & MV
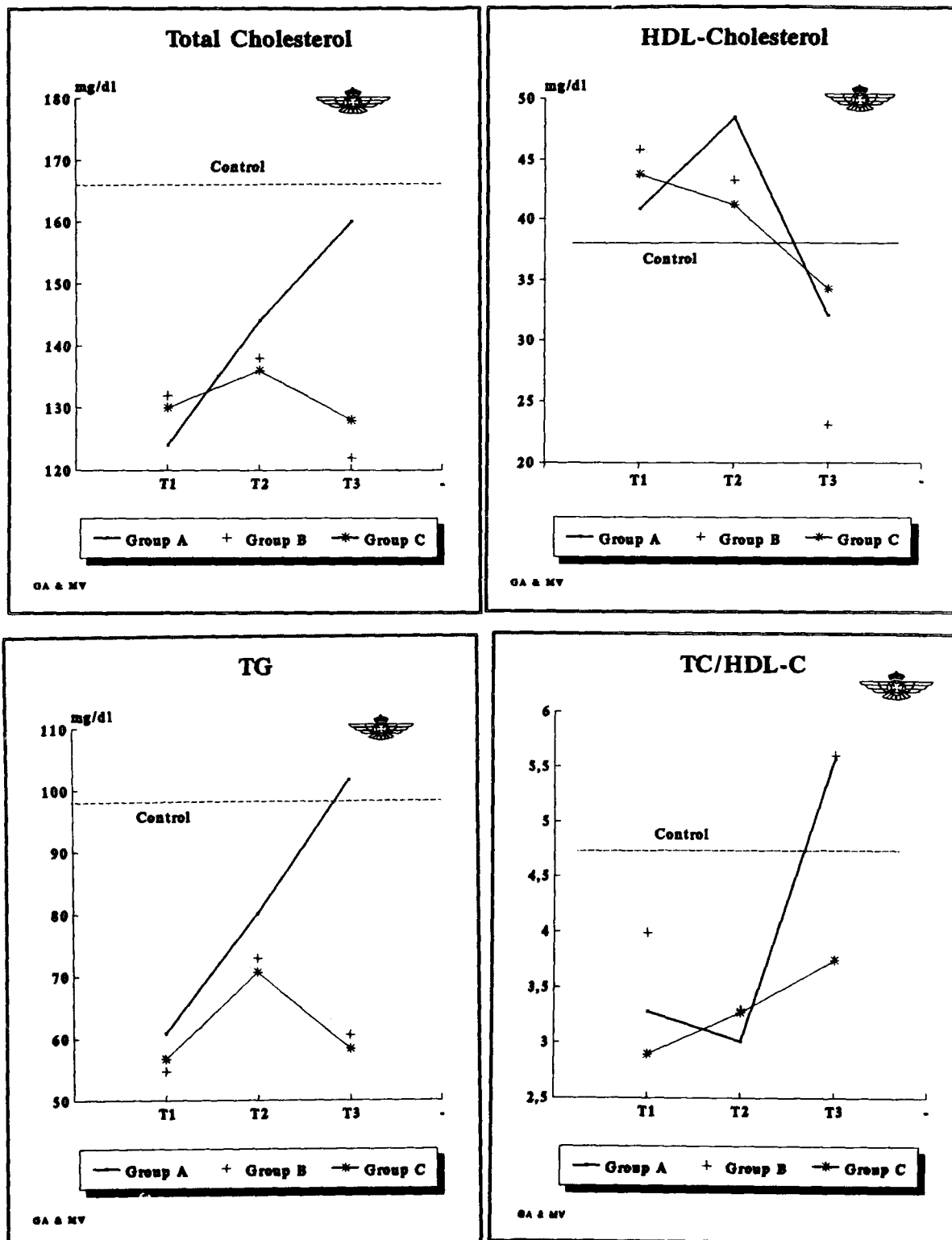
FIGURE 1

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THE INFLUENCE OF DIETARY COUNSELING AND CARDIAC CATHETERIZATION ON LIPID PROFILES IN AMERICAN MILITARY AVIATORS

by

B. Tuomala, R. Munson, W. Besich and P. Celio
Armstrong Laboratory, Internal Medicine Branch
Aeromedical Consultation Service
Brooks Air Force Base, Texas 78235-5000
United States

SUMMARY

The purpose of this study was to determine the combined effect of dietary counseling and cardiac catheterization on lipid profiles when compared to a control group that did not receive dietary counseling or cardiac catheterization. We reviewed the medical records and lipid profiles of 109 military aviators who underwent cardiac catheterization and dietary counseling and 109 matched controls who received neither. All individuals were seen twice at the Aeromedical Consultation Service (ACS) between July 1987 and March 1992. Lipid profiles of the two groups were compared during their first evaluation and again at follow-up. Overall, there was a trend towards improvement in lipid profiles, but the changes between the 2 groups were not statistically significant. The cardiac catheterization group was divided into 3 subgroups based on severity of disease and compared to their matched control. The subgroup with minimal coronary artery disease (max lesion ≤30%) showed a small but statistically significant improvement in HDL-cholesterol (p.0002). Otherwise the aviators knowledge of his angiographic results did not lead to any significant change in lipid profiles. This suggests that lipid profiles in aviators is not significantly affected by the combined influence of nutritional counseling and cardiac catheterization. The design of this study did not preclude members of either group from receiving dietary recommendations from physicians as part of their overall evaluation. This may account for the trend towards improvement in lipid profiles in both groups while masking the benefits of nutritional counseling.

INTRODUCTION

Extensive data implicates cholesterol in the atherosclerotic process responsible for coronary artery disease (CAD) (1-5). Premature CAD is the major nontraumatic cause of death in middle aged adult males. The importance of identifying individuals at risk for the development of coronary atherosclerosis in its early stages have led investigators to weigh the cumulative effects of various factors and how they are related. Clinical trials in humans have shown that lowering levels of serum cholesterol with diet or medication decreases the subsequent incidence of fatal or nonfatal CAD (4). Direct evidence of the benefits of cholesterol lowering obtained through clinical trials is strongest for middle aged men with initially high serum cholesterol levels (4). The optimum method of nutritional counseling and follow-up of those individuals at risk for CAD has not been defined. At the Aeromedical Consultation Service, aviators from the Air Force and Army are referred for evaluation of abnormal non-invasive cardiac testing. Coronary angiography is generally indicated in aviators with an abnormal treadmill test, abnormal thallium scan or calcification in the coronary arteries on cardiac fluoroscopy. Individuals that require cardiac angiography receive thorough nutritional counseling subsequent to the procedure. However, the

influence of nutritional counseling and cardiac angiography in reducing lipid levels has not been studied.

METHODS

Patients selected: All US Air Force (USAF) and Army aviators who required cardiac catheterization at the ACS to rule out the presence of CAD and returned for at least one follow-up evaluation between July 1987 - Mar 1992. **Controls.** A control group was constructed by a one to one match with each patient undergoing cardiac catheterization using the following variables: sex, age (+/- 6 months), TChol (± 10%) and evaluation dates (± 6months). No one in the control group had ever had cardiac catheterization or received formal dietary or cholesterol counseling.

Study Design: Retrospective Case Control Study
Setting: Aeromedical Consultation Service, Brooks Air Force Base, Texas. A central USAF referral center for evaluating aviators for flying fitness.
Laboratory Measurements: Total Cholesterol (TChol), Triglycericles, LDL cholesterol (Friedewald Calculation), HDL cholesterol, and TChol/HDL ratio measurements were obtained during both ACS evaluations. All laboratory tests were drawn at 0700 after a 12 hour fast.
Dietary Recommendations: All aviators who had a cardiac catheterization, were counseled by a registered dietitian or diet therapist. Patients were informed of individual lipid profiles, abnormal values and trends were emphasized. Prior to 1989, dietary recommendations to reduce fat and cholesterol were based on those of the American Heart Association "Approaches to Treating Hypercholesterolemia" Phase I-III (6,7). These guidelines were very general. Patients were instructed to decrease cholesterol and fat from their diets. In 1989, the National Cholesterol Education Program (NCEP) established specific guidelines for dietary intake of fat and cholesterol

(8). Dietary counseling was then modified to reflect the NCEP recommendations. Dietary counseling was also modified based on cardiac catheterization results. If the cardiac catheterization was normal or the lipid profile was favorable, patients were instructed to follow a diet with <30% of total calories from fat and reduce cholesterol consumption to <300mg/day. If the cardiac catheterization was abnormal or the lipid profile was unfavorable, patients were instructed to follow a diet with <20% of total calories from fat and reduce cholesterol to <200mg/day. All patients were also instructed to increase the percentage of complex carbohydrates consumed and to increase total fiber to 20-35 gm/day. Methods to alter recipes and evaluate food labels were discussed including calculating the percentage of fat in various food products. The benefits of aerobic exercise on weight, HDL cholesterol and chol/HDL ratio were emphasized and patients were encouraged to begin or continue an exercise program with approval of their physician. Guidelines were provided in achieving or maintaining desirable weight and body fat composition. Current eating habits were reviewed and suggestions for improvement were made.

RESULTS

Clinical Data: A total of 109 aviators who underwent cardiac catheterization met study criteria and 109 control matches were selected by computer search. Statistical calculations indicated a sample size of 109 would detect a change in total cholesterol of 15.5mg/dL with a power of 90% at a level of significance of .001. All subjects were male. The mean age was 42 years. The TChol at the initial evaluation was 216.4mg/dL for controls vs. 218.3mg/dL for the angiography group. The mean time between evaluations was 25.5 months. Table 1 demonstrates lipid profiles of the cardiac catheterization group and the control group at both evaluations. Tables demonstrate

raw data that has been rounded off. Percentages were calculated from raw data.

Table 1

	TChol	HDL	LDL	Ratio	Tri
CONTROL					
Eval #1	216.4mg/dL	45	144	5.2	138
Eval #2	207.9mg/dL	44	139	5.0	125
CATH					
Eval #1	218.3mg/dL	43	144	5.3	157
Eval #2	216.3mg/dL	45	143	5.0	143

The control group had a decrease in TChol of 3.9%; HDL decreased 2.8%; LDL decreased 3.2%; ratio decreased 5.0%; and triglycerides decreased 9.0%. The cardiac catheterization group had a decrease in TChol of 0.9%; and increase in HDL of 4.0%; a decrease in LDL of 0.3%; a decrease in ratio by 5.6%; and a decrease in triglycerides 8.9%. None of these changes were significant between the two groups.

The cardiac catheterization group was subdivided by results to determine if the patient's knowledge of the presence or absence of measurable coronary artery disease would influence lipid profile changes. These subgroups were defined as:

Normal	No gradable disease
Minimal Disease (MCAD)	Any single lesion ≤30% and aggregate[1] of all lesions ≤50%
Intermediate/ Severe Disease (ISCAD)	Any single lesion >30% and/or aggregate of all lesions >50%

These groups were compared to their one-to-one matched controls with the results shown in Table 2.

Table 2

	TChol	HDL	LDL	Ratio	Triglycerides
CATH/NORMAL					
Eval #1	213mg/dL	45	139	5.1	141
Eval #2	215mg/dL	46	142	5.0	133
CONTROL/NORMAL					
Eval #1	225mg/dL	44	153	5.7	138
Eval #2	215mg/dL	43	147	5.4	127
CATH/MCAD					
Eval #1	225mg/dL	40	152	5.7	165
Eval #2	216mg/dL	44	144	5.0	137
CONTROL/MCAD					
Eval #1	223mg/dL	45	151	5.4	136
Eval #2	216mg/dL	44	147	5.3	122
CATH/ISCAD					
Eval #1	231mg/dL	40	148	5.6	209
Eval #2	220mg/dL	41	144	5.4	198
CONTROL/ISCAD					
Eval #1	230mg/dL	43	158	6.0	141
Eval #2	214mg/dL	40	146	5.6	136

[1]The term aggregate is used as a measure of total atherosclerotic burden calculated by adding the percentage of all individual lesions.

The normal catheterization group (N=42) showed an overall trend of increasing lipid values. The TChol increased 1.2%; HDL increased 1.7%; LDL increased 2.3%; ratio decreased 0.6% and triglycerides decreased 5.8%. The controls for the Normal subgroup showed an overall trend toward improvement in lipid profile on follow-up. The changes in neither group were statistically significant.

The MCAD catheterization subgroup (N=28) showed the only statistically significant change. The Tchol decreased 3.8%; HDL increased 11.0% (p.0002); LDL decreased 5.1%; the ratio also decreased 1.3%; and triglycerides decreased 16.0%. The MCAD control subgroup also showed an overall improvement, but not as statistically significant. The ISCAD catheterization subgroup (N=15), showed a moderate trend toward improvement in lipid values. The TChol decreased 5.2%; HDL increased 0.5%; LDL decreased 2.5%; the ratio improved 3.5%; and triglycerides decreased 5.0%. The controls for this subgroup also showed a trend toward improvement in lipid values, but they were not statistically significant. Although all three groups do show trends, the only significant change seen was in the MCAD catheterization group with a significant increase in HDL and the resultant decrease in Tchol/HDL ratio.

Confounding Factors. To observe for possible confounding effects of diet, ETOH, smoking, weight loss/gain, body habitus, family history of premature CAD, and medications, a chart review was completed (108 cath, 107 control). Two charts lacked data and one was unavailable for review.

Diet - Thirty-nine percent of the catheterization group vs. 33% of the control reported following a regular diet with no restrictions, during both evaluations. Sixty-two percent of the catheterization group vs. 46% of the control reported following a diet low in fat and cholesterol or "prudent" diet. Only 14.3% of the catheterization group changed their diet from regular to low fat and cholesterol between

evaluations while 16% of the control reported this change. There was no record of any counseling done between ACS evaluations, but the charts reflected that ACS physicians had made dietary recommendations to many individuals in both groups.

ETOH - During both evaluations 13% of both groups abstained from alcohol. In the catheterization group 27% reported an intake of 1-2oz alcohol/day vs. 18% of the control group. Seventy percent of the catheterization group reported an intake of less than 1-2oz alcohol/day vs. 78% of the control.

Smoking - Twenty-one percent of the catheterization group reported to be currently smoking during ACS evaluations vs. 8% of the control group (p .008).

Weight Changes - Weight changes between evaluations was relatively the same between the 2 groups. Forty-two percent of the catheterization group gained between 1-10 lbs between evaluations vs. 46% of the control group. Thirty-four percent of both groups lost between 1-10 lbs between evaluations.

Body Habitus - Identification of ideal, overweight, obese body habitus was based on the Body Mass Index (BMI), a method for determining ideal body weight for height. The W/H^2 index (W=Weight in kg; H=Height in meters) has been found to have the highest correlation with independent measures of total body fat. A BMI greater than 27 is indicative of obesity. A BMI between 25 and 27 is defined as overweight, and if <25 it is considered ideal. During both evaluations 41% of the catheterization group was found to be in the ideal range vs. 60% of the control. Twenty-two percent of both groups was in the overweight category. Twenty-nine percent of the catheterization group was obese vs. 12% of the control (p.008). Eight percent of the cath group changed between evaluations, of those 4% (4) went from overweight to obese. Six percent of the control group changed between evaluations, of those 3% (3) went from overweight to ideal.

Family History - Thirty-five

percent of the catheterization group reported a positive family history for coronary artery disease vs. 26% of the control. **Medications** – A total of 25% of the catheterization group and 15% of the control took medication of any kind during the first, second or both evaluations. At the second evaluation 18 (17%) of patients from the catheterization group took medications known to affect lipids vs. 8 (7.5%) of the control. In the catheterization group 8 individuals had added, or took more effective lipid lowering drugs after their first evaluation. The most common drugs (cath, control) were: cholestyramine (2,2), niacin (2,1), lovastatin (2,0), gemfibrozil (2,0), colestipol (1,0), thiazides (4,2), and beta blockers (4,0). Some were taken in combination. Seventy-two percent of all medicated patients either showed a decrease or remained the same between evaluations regardless of the medication they were taking. Twenty-eight percent of the medicated patients had an increase in lipid values. To summarize, as compared to their controls, the catheterization group was influenced by the following: more alcohol use, greater number of active smokers, more categorized as obese, and a greater number with a positive family history for premature coronary artery disease.

DISCUSSION

Cardiac evaluation with coronary angiography is a significant experience for aviators. When one's livelihood is at stake the effect could be even more powerful. Therefore, it was expected that the experience of cardiac catheterization would provide additional motivation to improve compliance with dietary counseling. The data reported demonstrates no significant change in measured lipids between a group of aviators who had cardiac catheterization combined with dietary counseling compared to a control group, after follow-up at an average of 25.5 months. Both groups had a modest trend toward

improvement overall, while one would have expected the modest rise in total cholesterol normally seen with aging. However, both groups consisted of individuals evaluated at the ACS and all had complete lipid profiles measured and body fat estimates as part of the routine evaluation. Reviewing physicians often provided a diet recommendation to aviators who demonstrated elevated lipids or who were overweight. This alone may have accounted for the trend toward improvement seen in both groups. It may also have masked the effect of dietary counseling. Subgrouping by angiographic results was done for two reasons: first, it was expected that the graphic demonstration of disease to the angiographic subjects would again provide motivation to heed nutritional counseling. Second, the dietitians stressed their subject matter to aviators with known coronary artery disease. Again, there were not significant differences in normal vs. control and ISCAD vs. control subgroups. In the group demonstrating minimal coronary artery disease ($\leq 30\%$ obstruction) there was a small but statistically significant improvement in HDL and a lesser improvement in LDL cholesterol. It is difficult to explain this in terms of dietary counseling since the HDL is not as responsive to diet as other subfractions. The HDL level is, however, responsive to exercise and a regular moderate exercise program was routinely recommended to aviators with MCAD. In addition, the MCAD group may have been more motivated to maintain a regular exercise program since they would be disqualified from flying duties if they had any significant disease progression. Unfortunately exercise was not quantified in the medical record and the effect of this factor could not be tested. As this was a retrospective review one must be cautious of hidden bias. The possibility that ACS physicians may have provided dietary recommendations to both groups has been mentioned. Outside counseling could have been performed and would not have been

reflected in the records reviewed. We are encouraged that both groups in this study showed a trend toward improvement.

CONCLUSION

A single formal session of nutritional counseling in aviators who have had cardiac catheterization did not significantly improve lipid profiles as compared to the control population who had a medical evaluation but did not receive formal dietary counseling or cardiac catheterization. However, there was an overall trend toward improvement in lipid profiles in both the catheterization and control groups. This study suggests that a more aggressive approach to lipid management will be required perhaps using a more structured program of close and frequent follow-up.

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Biological Parameters and Cardiovascular Risk Factors
With the Flying Personnel Of the Belgian Armed Forces.

VASTESAEGER J-P. MD Lt Col , BAF; VANDENBOSCH P., MD Col. BAF VSM,
Quarters K.Albert I - Raketstraat 70 - 1130 BRUSSELS - BELGIUM.

INTRODUCTION :

Research has been done into biological parameters and cardiovascular risk factors of all pilots and navigators of the Belgian Armed Forces (Air Force and Light Aviation) of more than 45 years old and has been evaluated according to age categories. The evolution of these data has been analyzed with a retrograde study. Special attention has been paid to the differences between Light Aviation and Air Force and between the respective linguistic groups.

METHODS :

All the flying personnel of the Belgian Air Force and Light Aviation is annually examined in the Brussels Medical Center of Aerospatial Medicine. The medical files of all pilots and navigators older than 45 are analyzed. Attention is paid to anthropometric data (age, height, weight), to systolic and diastolic blood pressure, to smoking habits, to the total number of flight hours and to a number of biological parameters (glycemia, triglycerides, urea, creatinine, gamma GT, uric acid, cholesterol, HDL cholesterol). The results of the last full year (1990) are quoted as population values. Furthermore, the same data, if available, are quoted in a retrograde way every 5 years.

Composition of the Population: The examination concerns all members of the flying personnel (pilots and navigators) older than 45. This population is divided into two categories representing their particular Force: Category A representing the pilots and navigators of the Air Force and Category B representing the pilots of the Light Aviation. This division allows us to detect potential differences caused by a difference in recruitment and life style. The population is furthermore divided into 3 different age groups of 4 years each (from 46 to 49, from 50 to 53 and from 54 to 57) and also into linguistic categories (i.e. Dutch and French) because these divisions might reflect differences in cardiovascular risks in the total Belgian population.

Flight Hours. The total number of flight hours at the moment of the last medical examination (1990) is quoted.

Blood Pressure Measurement: The systolic and diastolic blood pressure is measured at the right arm, while sitting, using a mercury tensiometer. For the diastolic pressure Korotkoff tone 4 is usually quoted.

Smoking Habits: Smoking habits are checked and classified in accordance with the number of cigarettes smoked daily : 0: non-smoker, < 15: moderate smoker, > 15: heavy smoker. An ex-smoker is quoted as a non-smoker.

Biological Parameters : A blood examination with determination of biological parameters has only progressively been introduced in the selection and revision examination of the flying personnel. The rates of glycemia, uremia and cholesterol have been determined systematically from 1973 onwards.
Triglycerides, creatinine, uric acid and HDL cholesterol have been determined from about 1983 onwards. Gamma GT has only become a routine since 1988. the blood examination is carried out at the moment of recruitment (selection) and is repeated every two years until the age of forty, and every year after that age. To obtain as many results as possible from our pilots it is sometimes necessary to quote rates of one year earlier (reference years 1990, 1985, 1980, 1975 etc.). The blood sample is taken in the morning on an empty stomach.
For most values the laboratory tests are carried out in the laboratory of the Center of Aerospatial Medicine and for some values in the laboratory of the Brussels Military Hospital. The quality control of these laboratories and techniques meet required standards.
The biological tests and norms are represented in table 1. The year the test was initiated is also quoted.
Measurements exceeding the norm give rise to check-up examinations and possibly to treatment.

TABLE 1 : BIOLOGICAL PARAMETERS.

UNIT	NORM	STARTING YEAR
GLYCEMIA	70 - 100	1973
TRIGLYCERIDES mg%	60 - 200	1983
UREA mg%	15 -50	1973
CREATININE mg%	0.7 - 1.30	1983
GAMMA GT mu/ml	6 - 28	1988
URIC ACID mg %	1.8 -7.0	1983
T. CHOLESTEROL mg%	150 - 250	1973
HDL CHOL. mg%	40 - 70	1983

RESULTS:

Composition of the population: (Table 2) Of the total population of pilots and navigators in the Belgian Armed Forces all 115 were held back who were older than 45. This population is divided into 2 categories: Category A with BAF pilots (n=51, 44.3 %) and navigators (n=7 ; 6.1 %), and Category B with Light Aviation pilots (n= 57; 49.6%).
This population of 115 with an average of 49 years old is divided for analysis into 3 age groups of 4 years each: group 1(n= 71; mean age 47), group 2 (n=25; mean age = 51) and group 3 (n=19; mean age = 55). The population consist of 71 Dutch-Speaking and 44 French - Speaking pilots and navigators.

TABLE 2 : DIVISION OF THE POPULATION.

	DIVISION	NUMBER	%
TOTAL		115	100
CATEGORY	A: AIR FORCE	58	50.4
	B: LIGHT AVI.	57	49.6
AGE GROUP	1: (MEAN AGE 47)	71	61
	2:(MEAN AGE 51)	25	21
	3:(MEAN AGE 55)	19	18
LINGUISTIC	D= DUTCH	71	62
GR.	F= FRENCH	44	38

Anthropometric Parameters and Variables: (in 1990) (Table 3). The mean values for the whole population (n=115) with maximum, minimum and standard deviation are given for build, weight and flight hours. Furthermore, the blood pressure and the various biological parameters are quoted. Smoking habits are represented in % (percentage).

TABLE 3:ANTHROPOMETRIC AND BIOLOGICAL VARIABLES OF THE TOTAL POPULATION.

	MEAN	MAX	MIN	SD
HEIGHT	175	195	163	5.7
WEIGHT	78.9	104	53	8.6
FLIGHT HOURS	4130	10200	1160	1415
BP SYST(mmHg)	133	180	110	13.7
BP DIAST (mmHg)	82.6	120	60	9.0
GLYCEMIA (mg%)	81.7	121	60	11
TRIGLYC.(mg%)	148	489	48	84
UREA (mg%)	32	61	15	7.9
CREATIN(mg%)	1.18	1.68	0.85	0.139
GAMMA GT(mU/ml)	23.5	94	8	26.97
URIC ACID(mg%)	5.67	8.8	2.7	1.065
T.CHOLES(mg%)	243	380	147	45
HDL CHOL(mg%)	50	99	25	12.47
SMOKING HABITS	0 : 70 %	<15 : 16%	>15: 14%	

The evolution of the anthropometric and biological variables during the career as flying personnel is studied in a retrograde way.
In table 4 measurements are given insofar as sufficient data are available.
The significance of the difference is analyzed via a paired T Test.

TABLE 4: EVOLUTION OF THE VARIABLES:

	(n)	1970	1975	1980	1985	1990	SIGN
WEIGHT	(115)	73.3				78.9	***
SYST BP	(115)	127.3				133.4	***
DIAST BP	(115)	76.5				82.6	***
GLYCEMIA	(115)		81.37			81.78	NS
UREA	(109)		32.5			32.7	NS
T.CHOL	(111)		242.3			243.2	NS
TRIGLYC	(111)				147.4	148.9	NS
CREATININE	(109)				1.14	1.18	.001
URIC ACID	(92)				5.43	5.69	.012
HDL CHOL	(69)				51.15	49.89	NS
SMOKING	(115)						
0		51%		52%	52%	70%	
< 15		36%		35%	31%	16%	
> 15		13%		13%	11%	14%	

The subdivision of the total population into various groups and categories may enable us to detect and explain potential differences. In table 5 the mean values are represented in Total, for Cat A (AF) and Cat B (Lt Avn), according to age group and linguistic group (D and F). There was no significant difference between these groups and categories (T-test, chi sq for smoking habits). Only Total Cholesterol is higher (p=.021) for Light Aviation.

TABLE 5 : SUBDIVISION OF THE MEAN VALUES (mean and SD)

	CATA n=58	CATB n=57	AGE1 n=71	AGE2 n=25	AGE3 n=19	D n=71	F n=44
HEIGHT (cm)	175 (5.6)	176 (5.9)	175 (5.4)	176 (6.8)	174 (5.7)	176 (6.1)	175 (5.1)
WEIGHT (Kg)	78.7 (9.5)	79.1 (7.6)	78.9 (9.3)	80.6 (6.5)	76.5 (8.1)	79 (8.7)	78 (8.4)
FLYING (H)	3963 (1115)	4298 (1659)	4133 (1451)	4280 (1462)	3914 (1250)	4122 (1416)	4142 (1429)
BP SYS (mmHg)	132 (13.4)	134 (14.1)	132 (13)	137 (14)	132 (14)	134 (14)	133 (13)
BP DIAS (mmHG)	82.5 (8.2)	82.7 (9.8)	82.3 (9.3)	84.7 (7.6)	81 (9.4)	82 (10)	83 (7.4)
GLYCE (mg%)	80.2 (9.4)	83.3 (12.3)	82. (11)	80.8 (12.2)	82. (9.2)	82 (11.5)	81 (10.2)
TRIGLY. (mg%)	141 (67)	155 (98)	151 (90)	150 (80)	135 (67)	155 (90)	139 (74)
UREA (mg%)	33 (7.4)	32.3 (8.5)	33.2 (8.2)	32.2 (8.3)	31.4 (6.7)	32 (7.8)	34 (8.2)
CREAT (mg%)	1.18 (0.127)	1.19 (0.151)	1.19 (0.14)	1.17 (0.13)	1.17 (0.13)	1.17 (0.13)	1.22 (0.15)
GAM GT (mU/ml)	25.7 (25.8)	23.2 (22.0)	25.9 (27.7)	25.7 (19.)	17.7 (9.10)	25 (23.9)	24 (24.3)
UR AC (mg%)	5.8 (1.16)	5.5 (0.93)	5.7 (0.90)	5.9 (1.3)	5.16 (0.13)	5.5 (1.07)	5.8 (1.04)
T.CHOL (mg%)	233 (43)	253 (45)	239 (44)	252 (45)	247 (50)	245 (46)	240 (44)
HDL C (mg%)	50.2 (12.6)	49.7 (12.4)	49.9 (13)	51.7 (12.9)	48.1 (9.6)	49 (11.8)	52 (13.4)
SMOKE							
0	67	72	75	68	52	66	75
<15	19	14	17	16	16	16	18
>15	14	14	8	16	32	18	7

Individual Exceeding of Norms. The number of people exceeding the accepted norm is determined for each parameter. The division of the population is analyzed and found to be gaussian for each parameter.

TABLE 6: EXCEEDING OF NORMS.

	NORM	n EXCEEDING
HEIGHT (cm)	> 196	0
WEIGHT (Kg)	(Height-100) + 20	0
BP SYST (mmhg)	100 -150	8 >150
BP DIAST (mmHg)	60 - 90	13 >90
GLYCEMIA (mg%)	70 - 100	13 < 70; 4 > 100
TRIGLYC.(mg%)	60 - 200	6 < 60 ; 21 >200
UREA (mg %)	15 -50	2 >50
CREATIN (mg%)	0.7 - 1.30	14 >1.30; 50 > 1.20
GAM GT (mU/ml)	6 - 28	28 > 28
URIC ACID (mg%)	1.8 - 7.0	8 > 7.0
T.CHOL (mg%)	150 - 250	1 < 150; 46 >250
HDL CHOL (mg%)	40 -70	19 < 40; 7 > 70

COMMENTS.

It is useful to evaluate the various examination results concerning a well-defined target group (like FP) at regular intervals. This should help us to get an idea of the state of health of the total group and of the individuals in this group. This information allows us to define a group norm. This kind of study also allows us to develop strategies for research policy and possible preventive campaigns. When considering our own results we find that in general the mean values stay within acceptable norms, i.e. acceptable to us.

The relatively high values for creatinine (mean 1.18 mg%) and Total Cholesterol (mean 243 mg%) are perhaps questionable.
When evaluating individual though, we notice that a relatively important group of people clearly exceeds the normal values and moves away from group averages. A discussion of these results, when compared with the group norm, is highly motivating for treatment and prevention. As shown in table 6 the exceeding of the norms is rather important for triglycerides, gamma GT, creatinine, T Cholesterol and HDL Cholesterol. The division of the population for weight and gamma GT clearly singles out these people. Advice and appropriate measures with respect to diet are certainly required. The longitudinal follow-up of data offers us an insight in the evolution of the parameters with respect to the age of the people concerned. Here too, the evolution stays within acceptable values. As expected , weight and blood pressure rise, yet the population can still be considered as a homogeneous group.

An efficient comparison with earlier mean values is not so simple though, due to fact that the various biological parameters have been introduced over a longer period of time (historical spreading). Here again, no striking evolution is noticeable. Only for non-smokers such an evolution can be noticed: the number of non-smokers increases from 51% to 70%, moderate smokers stop (from 36% to 16 %), but heavy smokers persevere in their evil habit (13 % - 14 %). This trend has been noticeable since 1980. The conclusion that heavy smokers are more difficult to motivate seems to be affirmed by other studies. This particular group should therefore become the target of a specific campaign.
The further division of the total population into subdivisions enables us to evaluate potential differences. Selection and life style of categories A and B differ to some extent, which leads us to survey. Only Total Cholesterol is higher (p=.021) for Light Aviation.
The subdivision into age groups shows no differences, which implies that the total group (n=115) may be considered homogenous.
The difference between Dutch-speaking and French speaking people as shown in some Belgian surveys does not exist for our flying personnel.

Only the higher number of heavy smokers in the D group (18 % as opposed to F 7%) and in the older age group (32% as opposed to 8%) is striking. We do not have an immediate explanation for this. A More detailed analysis of smoking habits is advisable.

CONCLUSION.

Keeping a good systematic record of anthropometric and biological parameters is essential and ought to be part of a strategy of selection, support and prevention. The introduction of informatics in this field ought to be organized simultaneously with a standardization to enable a comparison with other population groups and other air forces (role AGARD?).
In practice the results of the survey should be used to motivate individuals for healthy life style. A better control of eating and smoking habits may reduce the number of times the norm is exceeded.

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CHANGES IN SOME "LIFESTYLE PARAMETRES" IN NORWEGIAN PILOTS AS STUDENTS, AND AFTER 6 AND 12 YEARS OF SERVICE

I.L. Neslein, C.C. Christensen, L. Lian, T. Rode, and H.T. Andersen

Royal Norwegian Institute of Aviation Medicine,
P.O. Box 14 Blindern, 0313 Oslo, Norway

Summary

Medical records from candidates accepted for military training in the Royal Norwegian Airforce (RNoAF) between 1978 to 1980, and who still are on flying standards in the RNoAF, have been examined.
Cholesterol, HDL-cholesterol, resting heart rate, blood pressure, body weight, and maximum oxygen uptake have been studied over a 12 year period, i.e. at approximately 20, 26 and 32 years of age.
Our pilots gain weight at a rate twice that of the general Norwegian population. They maintain the same physical fitness from the age of 20 to 26, and from 26 to 32 there is a significant increase in maximum oxygen uptake. A 32 year old pilot is in a distinctly better physical condition, both compared to his younger collegues, and to the average Norwegian of the same age. There is also a significant increase in serum-cholesterol from the age of 20 to 32. HDL-cholesterol and resting heart rate remained unchanged over the periode. Systolic blood pressure was unchanged from 20 to 26, but decreased significantly from 26 to 32. Diastolic blood pressure dropped significantly from 20 to 26 years of age.
Dietary/lifestyle consultation, as a matter of routine, may be of great importance to young pilots in order to prevent coronary heart diseases in the future. Such information should be given at an early stage, before symptoms occur.

INTRODUCTION

Medical selection for pilot training in the Royal Norwegian Airforce (RNoAF) is performed at the Institute of Aviation Medicine. All candidates are expected to meet the medical standards for fighter pilots.

The average age of candidates applying for pilot training is 20 years. After selection, Norwegian military aviators are medically re-examined at our institute at 6 year intervals until age forty, thereafter, every three years. In addition, annual or semi-annual medicals are performed at their local airforce bases.

Compulsory service time in the RNoAF after initial pilot training was until recently 10 years (now it is 12 years). After this period, the majority of the pilots leave the air force to fly for commercial airlines. As a result, a large group of pilots have left the service by the age of 32, which is frequently time for a third medical examination at our institute.

Cholesterol, HDL-cholesterol, resting heart rate, calculated maximal oxygen uptake, blood pressure and body weight are measured at each medical examination, likewise, a number of serum-enzymes are determined.

METHODS

Medical records from candidates accepted for military pilot training between 1978 and 1980, and who still are on flying standards in RNoAF, have been examined. This includes 36 pilots flying fighters, multiengine- and rotary wing aircrafts.

Serum lipides have been analysed according to standard clinical chemical methods set by the International Federation of Clinical Chemistry

Blood pressure is measured in a sitting position after 5 minutes of rest. Heart rate is measured in a supine position from the ECG-recordings.

Maximum oxygen uptake is estimated from the heart rate at single submaximum work load on a bicycle ergometer, using the Åstrand-Rhyming nomogram (1). The bicycle ergometer is electromagnetically braked with pedalling rate set at approximately 60 rotations per minute. The ambient temperature at which the pilots performed the tests was kept between 18 and 20 degrees Celcius. The work load was initially set to 100 Watts, and the heart rate was observed during 2-3 minutes of exercise. The work load was then adjusted so that the heart rate after 6 minutes of cycling would stay in the range of 130 to 170 beats per minute. The rate was considered stable if it differed less than 5 beats per minute during the 5. and 6. minute of testing. Maximum oxygen uptake was estimated by calculating the average heart rate of the last two minutes, using the age-correction factor according to Åstrand (1).

The data have been statistically analysed by Student's paired t-test. Levels of probability less than 0,05 are considered significant.

RESULTS

Military pilots examined in this study gain weight as they grow older. We found a significant increase from the age of 20 to 26, and from 20 to 32. Over the 12-year period, the pilots increased their weights by 10,5%.
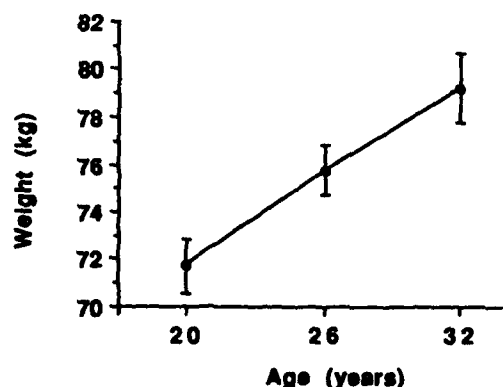

Fig. 1: Changes in body weight in Norwegian military pilots from the age of 20 to 32 (n=36). There was a significant increase from 20 to 26, and from 26 to 32 years of age (p<0,05). Results are given as mean values ± SE.

Maximum oxygen uptake remained unchanged from the age of 20 to 26, but increased significantly from 26 to 32. Thus a 32 year-old pilot has a 8% higher oxygen uptake than a 20 year-old candidate applying for pilot training.
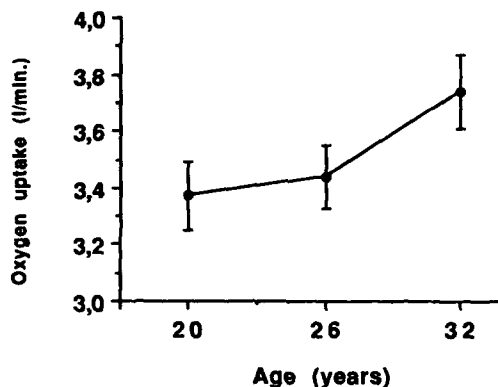

Fig. 2: Changes in maximum oxygen uptake in Norwegian military pilots from the age of 20 to 32 (n=36). The pilots maintained the same physical fitness from 20 to 26 years of age, but increased it significantly from 26 to 32 (p<0,05). Results are given as mean values ± SE.

Serum-cholesterol levels did not change significantly, neither from the age of 20 to 26, nor from 26 to 32, but there was a significant change from 20 to 32 (p<0,001).
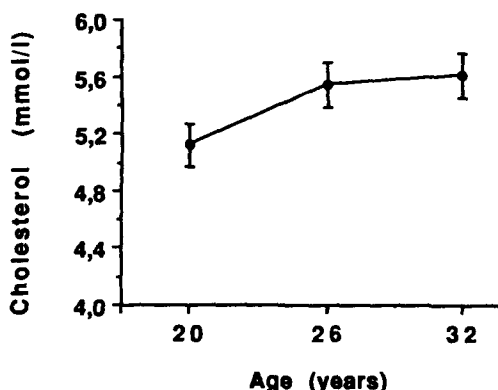
Fig. 3: Changes in seum-cholesterol in Norwegian military pilots from the age of 20 to 32 (n=36). There was no significant change neither from 20 to 26, nor from 26 to 32, but there was a highly significant increase from 20 to 32 (p<0,001). Results are given as mean values ± SE.

HDL-cholesterol and resting heart rate remained unchanged over the period of 12 years.

Systolic blood pressure did not change from the age of 20 to 26, but decreased significantly from 26 to 32. Diastolic blood pressure decreased from 20 to 26, and thereafter remained unchanged.

Fig.4 Changes in systolic blood pressure in Norwegian military pilots from the age of 20 to 32 (n=36). There was no significant change from 20 to 26, but decreased significantly (p<0,05) from 26 to 32 years of age. Results are given as mean values ± SE.
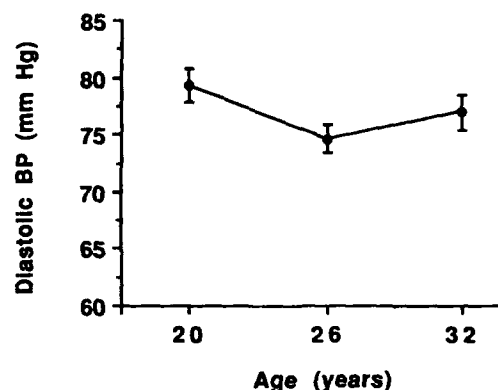
Fig. 5 Changes in diastolic blood pressure in Norwegian military pilots from the age of 20 to 32 (n=36). There was a significant decrease from 20 to 26 years of age (p<0,05). From 26 to 32 there was no change. Results are given as mean values ± SE.

DISCUSSION

A remarkable weight increase was recorded in pilots compared to other Norwegian males of the same age. At 20, the average weight of a Norwegian male is 69,0 kg ± 0,18 (2), whereas the young pilots had a mean of 71,7 kg ± 1,17 (fig.1). The weight gain in pilots from 20 to 32 was more than twice that og the general Norwegian population. On the average pilots increased their body weight by approximately 10,5% (fig.1), while the average Norwegian male only put on 4,6% during this period (3).

If the increase in body weight from 20 to 26 is related to an increased muscle weight, one would expect an increase in oxygen uptake, but this did not happen (fig.2). The pilots maintained the same physical fitness during this period. The weight-increase is most probably due to fat. The unchanged heart rate points to the same conclusion, assuming that an increased level of physical activity would lead to a decrease in resting heart rate.

We have not performed any measurements in order to estimate the body composition of fat and muscular mass, but the increase in serum-cholesterol from the age of 20 to 32 (fig.3) might indicate a diet relatively rich in cholesterol-increasing compounds.

As mentioned above, the pilots maintained the same physical fitness from 20 to 26, but from 26 to 32 there was a 8% increase in oxygen uptake (fig.2). Pilots, like all military officers, are obligated to maintain a minimum level of physical fitness, therefore, displaying a higher average maximum oxygen uptake than the general Norwegian population (1). The average Norwegian male in his twenties has a average oxygen uptake of 3,39±0,29 l/minute, and the young pilots/pilot students, thus, fit in very well (fig.2). However, when the pilots reach their thirties, the difference between them and the Norwegian population in general, is highly significant. The pilots averaging at 3,74 ± 0,13 l/min when in their thirties, whereas the general Norwegian male has a mean of 3,09±0,29 l/min. (1).

The method by which maximal oxygen uptake is calculated is somewhat unprecise when used to compare different individuals, but as a tool for monitoring a single individual over a long period of time it is suitable (2).

All tests are performed at the RNoAF Institute of Aviation Medicine, using the same equipment, and to a great extent, by the same technicians at all times. Even though the method has its disadvantages, an increase of 8% in 12 years, performed as described, can not be explained due to technical inconsistencies.

The significant increase in oxygen uptake took place about 1985/86, when the pilots were in their mid-twenties. This also was the time when the general trend in the Norwegian population appered to be increasingly concerned about lifestyles. This might have influenced our pilots, and, to some degree, explain the increase in physical fitness. The increased body weights could then be explained by an increased muscle mass and not an increase of fat. But then one would also expect a drop in resting heart rate and serum-cholesterol, which we did not observe. To the contrary, serum-cholesterol increased significantly over the period of 12 years. But the increase was quite slow, there was no significant elevation from the age of 20 to 26, but there was a distinct one from 20 to 32 (fig.3).

The conclusion to be made from this study is that general lifestyle consultation is of importance to our pilots. Moreover, this ought to be emphasized at an early stage of the pilots´s careers. It is well documented that serum-cholesterol, body weight, blood pressure, etc. all are reliable predictors when calculating the risks of coronary heart diseases, and that these factors can give information about future disease problems, long before any symptoms occur. This has been done in the RNoAF since the mid-eighties. Until that time, only personell with severely elevated serum-cholesterol levels and/or body weights received nutritional consultation as a matter of routine.

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SURVEY OF SMOKING HABITS IN THE SPANISH AIR FORCE

Maj. F. Rios Tejada
Maj. C. Alonso Rodriguez
Maj. J. J. Cantón Romero
Cpt. J. A. Azofra Garcia

Centro de Instrucción de Medicina Aeroespacial
Spanish Air Force
Arturo Soria 82. 28027 Madrid. SPAIN

SUMMARY

Cigarette smoking is a well known cause of major illnesses in the general population, illnesses than can impare a pilot's performance of duty and even result in temporary or permanent disqualification of the aircrew member.

This results in a diminished return on a significant investment of time and resources used to train the individual, a loss that is even more critical as the competition for such resources in an era of budget reduction, becomes more intense.

The purpose of this paper is to review the diseases and physiologic changes related to cigarette smoking, especially as they relate to the flying environment. We will then specifically examine the prevalence of both the smoking habit and these related impairments in the Spanish Air Force aircrews. Finally, we will utilize this data, compared to previous epidemiologic surveys in this target population, to draw conclusions regarding the effectiveness of past efforts at reducing cigarette smoking and propose future methods that might be used to reduce the negative impact of smoking related illness on the SAF mission.

INTRODUCTION

Cigarette smoking is widely recognized as the major preventable cause of many disabling and lethal diseases, which in recent years have increased in epidemic proportions. Illnesses directly related to smoking include emphysema, bronchitis and cancers of the lung, larynx, and bladder. Other maladies in which smoking is a major contributing factor include coronary artery, cerebrovascular and peripheral artery diseases (1).

The eradication of the smoking habit should be a major objective of the medical community. More than 25 years ago the Royal College of Physicians of London started an ambitious program to eliminate smoking among medical personnel and a wide campaign to decrease cigarette consumption in the general population.

This effort has resulted in a decrease in the prevalence of smoking in U.K. physicians to less than twelve percent while new laws have been enacted over the last two decades providing greater regulation of the tobacco industry (2,3).

The success of the British Medical Community should inspire other groups of physicians to construct their own antismoking programs. Although these campaigns would differ based on different socie tal, cultural and economic factors unique to each locale, they should all share these common goals:

1. Reduce the number of young people who start smoking.

2. Reduce the number of adults who currently smoke.

3. Decrease the number of cigarettes smoked per day in the population that continues to smoke.

4. Protect the non smoking population from the effects of passive smoking.

5. Create a negative social environment against the habit.

The need to aggressively attack cigarette smoking is even more pressing in the aeromedical community. Chronic exposure to cigarette smoke has been demonstrated as disabling among aircrewmembers (4,5), it is associated with 80-90% of chronic obstructive pulmonary disease (COPD) morbidity and mortality, including an increased prevalence of respiratory tract infections and thus higher incidence of temporary disqualifications for flying duties. The long term effects were demonstrated when quantitative spirometry performed in commercial airline pilots showed that minor-to-moderate spirometric impairment existed in 12% of this population and was highly correlated with age and cigarette smoking (6,7). Chronic cigarette smoking has been shown to increase the elastolitic activity locally and decrease the amount of functional alpha - 1 - antitrypsin (α1AT) in the lung. Serum levels of α1AT were elevated in smokers, possibly reflecting the effects of chronic inflammation or due to a positive feedback mechanism responding to the above mentioned diminished pulmonary α1AT (8).

The incidence of lung cancer and its direct relation to cigarette use is well known. Investigation of the cellular changes in bronchoalveolar lavage (BAL) secondary to tobacco smoking, and their relationship to the development of lung cancer has included the analysis of T-lymphocytic subpopulation CD4 and CD8 by indirect immunofluorescence with monoclonal antibodies. In smokers the BAL has shown a significantly decreased number of CD4 lymphocytes in comparison with the non smoker group. This inversion of the CD4/CD8 ratio in the smokers could signify the presence of a secondary local inmunosupression, a situation that could predispose to the subsequent development of tumor and to a higher risk of respiratory infections (9).

Like engine exhaust fumes, smoking can cause carbon monoxide poisoning. This can prove to be a significant danger when combined with the hypoxemic environment of high altitude, a problem that is magnified at night. Dark adaptation time has been demonstrated longer, and light sensitivity of the dark adapted eye, reduced in smokers as compared to nonsmokers, felt to be secondary to chronic poisoning with carbon monoxide (10). Smokers have levels of carboxyhemoglobin from 2 to 15 times higher than nonsmokers, thus reducing the amount of hemoglobin available for oxygen transport. Also, carbon monoxide may produce intimal hypoxia and increase endothelial permeability in the arterial wall which may favor lipid deposition, obviously raising the likelihood of developing significant atherosclerosis (11).

The dangers of cigarette smoking have been established beyond reasonable doubt and health professionals must continue to find better ways to efficiently educate the population of these dangers, including the public, politicians and most importantly aircrewmembers.

In order to effectively educate this people one must identified who they are. This process of identifying the target population has been conducted over the last decade utilizing a variety of surveys aimed at evaluating the smoking prevalence in the civilian and military community (12,13,14,15,16).

Habits which enhance the exposure of the bronchial epithelium to cigarette smoke increase the risk of bronchial carcinoma, produces structural and functional abnormalities in the airway mucociliary system and increase the number of inflammatory cells which can release elastase in the lung (6,7,8). Spirometric indices based on pulmonary function test (FVC, FEV1, Vmax50) are significantly related to the daily dose of tar, nicotine and CO (17), and symptoms of cigarette smoking related to tar yield and number of cigarettes smoked (18). The sympathomimetic effects of the nicotine increases the blood pressure, heart rate, cardiac output and coronary blood flow with a vasoconstriction of peripheral arteries. Smoking is also associated with increased platelet aggregation and plasma fibrinogen which is favoring blood viscosity and therefore raising the likelihood of thrombotic events. All these factors affecting the general smoking population are even more critical to individuals who have to fly. This specific community is required to demonstrate their good health and their ability to fulfill the psycophysiologic requirements of the civilian, military, national and international aviation regulations.

These regulations establish examination procedures, testing requirements and medical standards that clearly determine the appropriate aeromedical disposition for the fliers who show any disability related to the smoking behavior.

However the main goal in smoking intervention should be to avoid this behavior in the first place, preventing the development of smoking dependence. Smoking nearly always begins in adolescence for psychosocial reasons, including parental smoking, curiosity, smoking among friends, assertion of independence and rebelliousness. The military service and military academies provide the greatest opportunity that the Government Health Agencies have available to promote a nonsmoking environment by providing information on risks associated with tobacco. There was a dramatic rise in deaths from respiratory diseases between the early 1940s and the late 1970s in the UK. The age standardized rates from 27 per 100.000 to 92 per 100.000 during this peak period of cigarette smoking (19). That figures of the general population could include the flying personnel and it is easy to understand there is a general agreement among NATO countries that smokers should not have millions of dollars invested in them for aviation training. However at this time it is virtually impossible in most countries to limit the population of flyers at present because of the high prevalence of cigarette smoking. Thus the pulmonary function test and exam become the major means to differentiate the "high risk individuals" from the average smoker and also offers the best opportunity to educate all aircrew candidates.

If from a strict medical viewpoint we can find a means of giving a pilot an extra half or one G: 1) by selecting people who have lungs that will give them optimal ventilation-perfusion matching (20), 2) by providing a better dark adaptation by decreasing the carbon monoxide exposure (10), 3) by improving the hypoxic tolerance by avoiding the shifting of the HbO2 dissociation curve to the left (21), then we should do so.

A major concern among flight surgeons should be the prevention of those illness which constitutes by itself a sudden risk in air operations. Coronary artery disease and smoking is very intimately linked to sudden death and there is epidemiological evidence that the sudden death mortality rate in smokers of more than 20 cigarettes/day were 3.36 against a rate of 1.00 in non smokers (22).

A more immediate danger to the smoking aircrew member might be the risk of developing spontaneous pneumothorax as a result of a sudden decrease in atmospheric pressure, a risk which has been shown to be increased in cigarette smokers, especially those who fit the profile of being tall, aged 15-25 years and who did not regularly participate in sports or other hard physical activity (23).

It should be a major objective among military health providers to raise the likelihood that aircrews will abandon their smoking habits (24). Active intervention will prolong the flying career of the aviators, both by decreasing the incidence of smoking related diseases (including sudden death), and by improving flying safety.

After 8 years of an active antismoking campaign aimed at aircrew who regularly completed their physiological training in our Institute, a new survey was established in order to evaluate the effectiveness of this continuing program of educating our fliers by determining the prevalence of smoking and related symptomatology.

MATERIAL AND METHOD

A number of 845 questionnaires has been completed. Survey was a non randomized, totally anonymous, and directly addressed by medical personnel of the SAF Aeromedical Center and Flight Surgeons.

Population were all males and their ages ranged between 18 and 59 years (average 31).

Following of the World Health Organization (WHO), in relation to smoking habit, we have distinguished four different categories:

1- Daily smokers, those individuals that at this time smoke under daily bases (13).

2- Occasional smokers, those individuals who smoke but not daily.

3- Ex-smokers, those individuals, who do not smoke at this time, but they had smoked in the past 6 months or more.

4- Non smokers, people who never smoke.

Survey has eight aircrew categories: pilots (fighter, cargo, helicopter), undergraduate pilots, mechanical engineers, controllers, paratroopers and medical personnel.

Each questionnaire includes age, category, squadron, smoking habit, number of cigarette/cigars/pipes per day and symptoms associated to tobacco users. Questionnaire responses were uses to define the symptoms, chronic cough and phlegm, wheeze and exertional dyspnea.
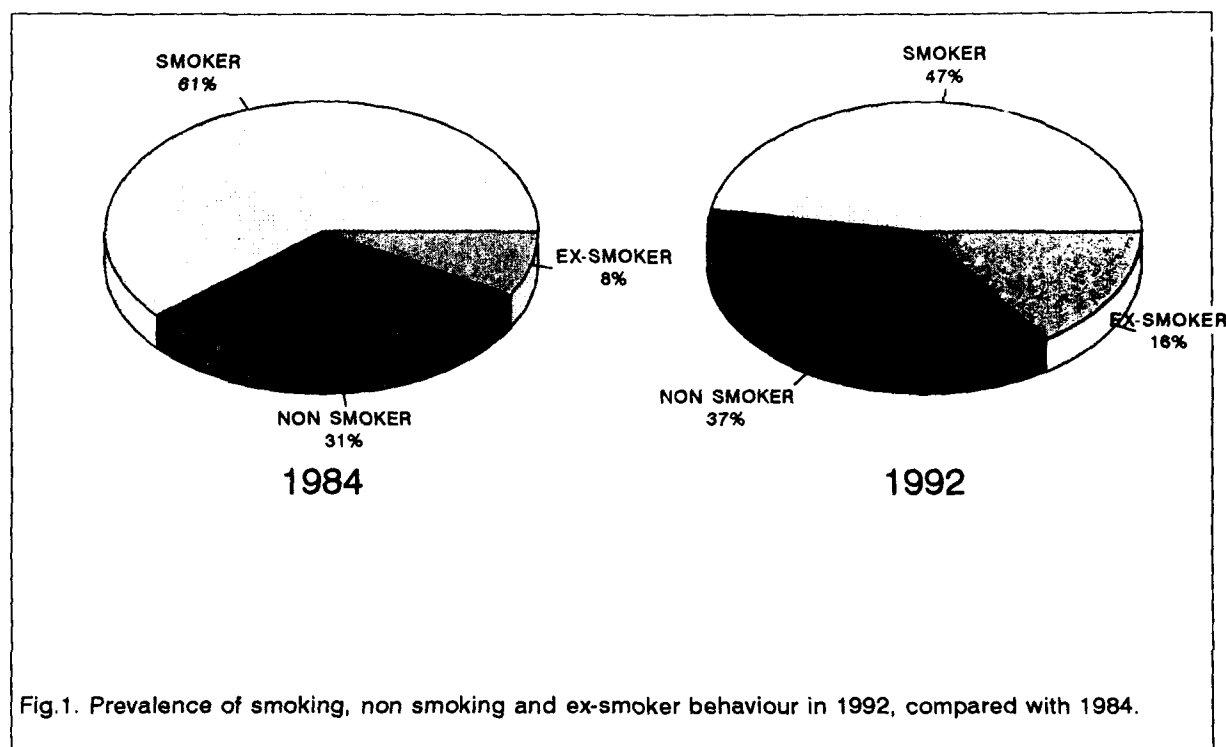
Fig.1. Prevalence of smoking, non smoking and ex-smoker behaviour in 1992, compared with 1984.

Statistical analysis has been performed by the calculation of mean values and distribution of data. We used logistic regression to analyze the relationship of the prevalence rates of symptoms, number of flying hours and smoking habit.

RESULTS

Prevalence of smokers is 47.2%, non smokers is 37.15% and ex-smokers 15.62%. See Figure 1.

Distribution by categories show the highest rate among helicopter pilots (20.3% out of smokers group and 9.5% out of the total population studied), mechanical engineers (19.5% out of smokers and 9.2% of the total number) and cargo pilots (17.5% out of smokers and 8.2% out of the total number). Figure 2 shows data by categories.

Figure 3 shows percentages of incidence separated by range of age, groups has been divided in 20 - 30, 31 - 40, 41 - 50 and 51 60 years old.

Table 1 describes average in years of length of smoking habit divided by group category and data corresponding to average in years of quit smoking time.

Percentages figures of average number of cigarettes per day separated by group category (see Table 2), shows the major consumers are the mechanical engineers (10.28), following by controllers (9.1), cargo pilots (7.5), paratroopers (6.9), medical (6.7), fighter pilots (6), helicopter pilots (5) and cadets (4)

The relation between smoking habit and related symptoms is displayed in Figure 4. Note symptoms have been divided in pulmonary (repetitive morning coughing, sputum or dyspnea), presence of demonstrated pulmonary cancer, bladder, mouth, esophagus or larynx cancer and cardiovascular symptoms

Relation with flying time give us an idea of how stresses of flight can influence the tobacco consuming (see Figure 5).

We found non statistically significant correlation between rate of symptoms, number of flying hours and tobacco use.

	Years of smoking	Years since quit
FIGHTERS	15	7
CARGO	12	4
HELICOPTERS	13	75
CADETS	5	6
PARATROOPERS	8	7
CONTROLLERS	14	45
ENGINEERS	115	65
MEDICAL	45	4

Table 1 Average of smoking time lenght against time since quit smc   by group category

DISCUSSION

Eight years ago the SAF Aeromedical Center completed a survey in order to evaluate the prevalence of smoking habits among SAF aircrews. Results showed that 61.9 % of the population interviewed (total number of 1.061) were smokers, 30.89% of non smokers and 8.29% of ex-smokers (12). Prevalence of smoking in some other group of population ranged between 49% and 60% (13,14,15,16).

The decrease of 14.7% rate of smoking prevalence, the increase of 6.26% rate in the number of non smokers and the increase of 7.33% in the population of ex-smokers, after 8 years of active campaign against tobacco are rewarding figures but still far away from other NATO nations and from our expectations.

SMOKER
40%

EX-SMOKER
20%

NON SMOKER
40%

FIGHTERS

SMOKER
42%

EX-SMOKER
18%

NON SMOKER
40%

CARGO

SMOKER
60%

NON SMOKER
19%

EX-SMOKER
21%

HELICOPTERS

EX-SMOKER
2%

SMOKER
30%

NON SMOKER
67%

CADETS

SMOKER
45%

EX-SMOKER
11%

NON SMOKER
45%

PARATROOPERS

SMOKER
46%

EX-SMOKER
20%

NON SMOKER
35%

CONTROLLERS

SMOKER
63%

EX-SMOKER
17%

NON SMOKER
20%

ENGINEERS

SMOKER
49%

EX-SMOKER
3%

NON SMOKER
49%

MEDICAL
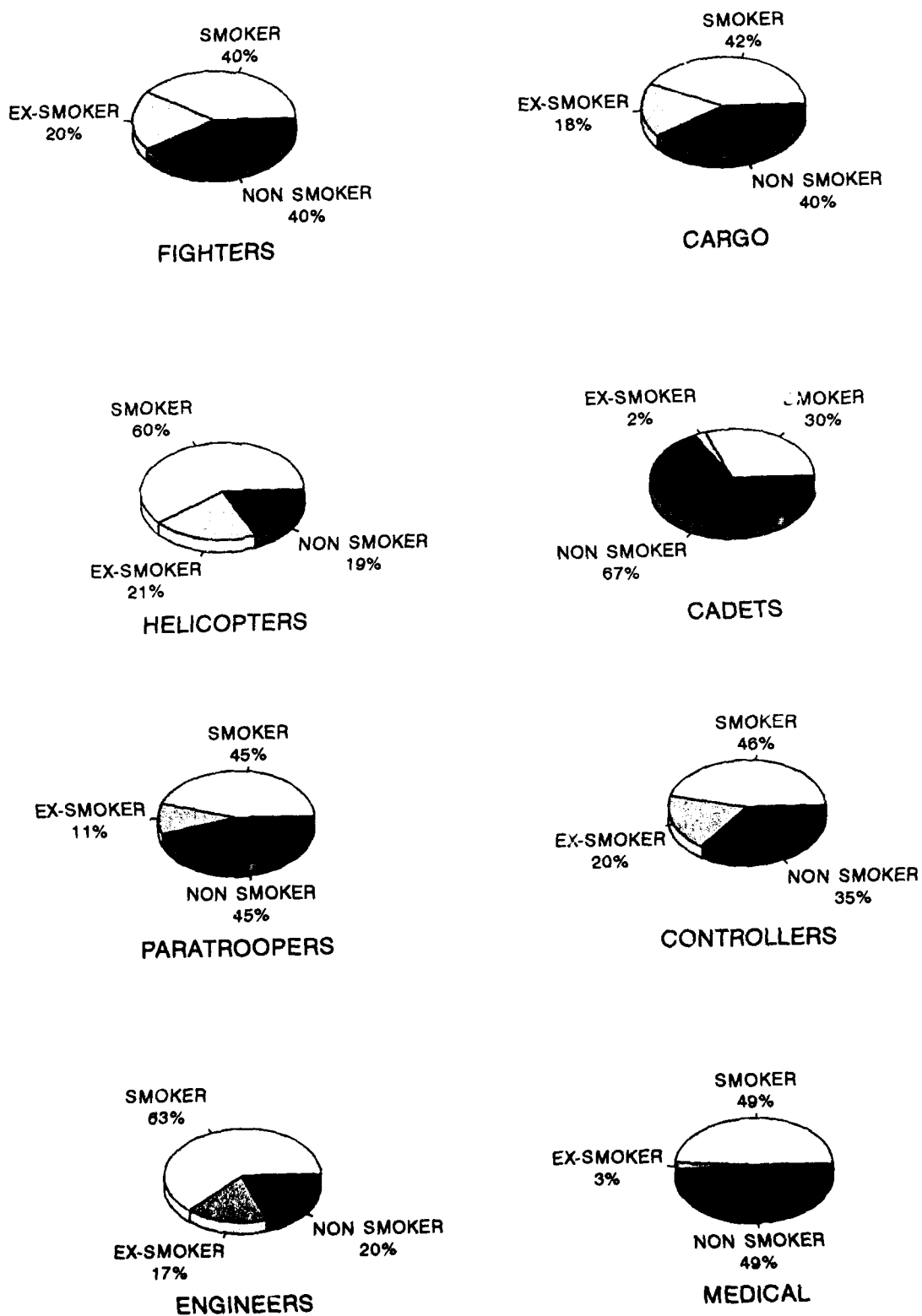
Fig.2. Prevalence of tobacco consuming by group category.
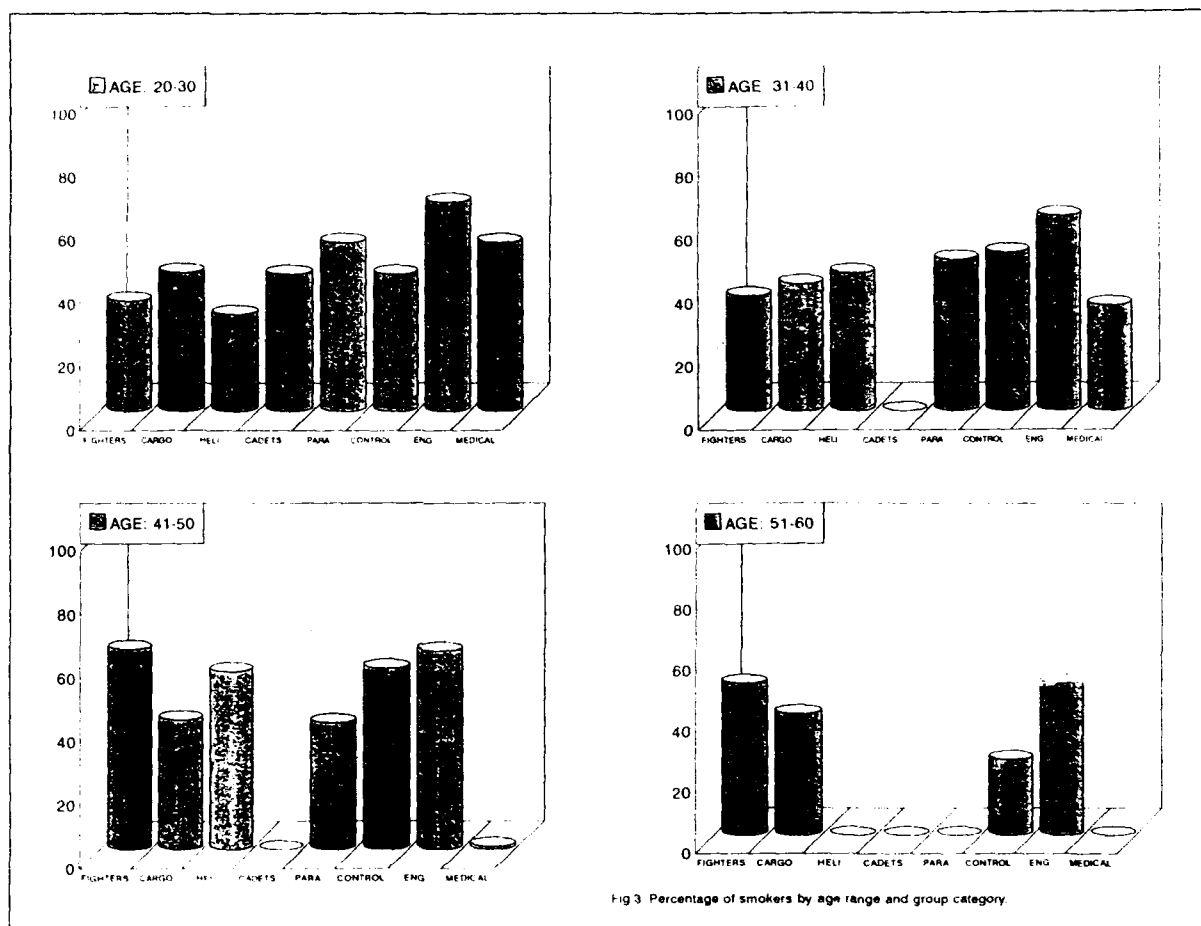
Fig 3 Percentage of smokers by age range and group category.

This high prevalence rate should be a reflection of the general population, but our data shows even lower rates than some other studies made in Spain (12,13,14,15,16), see Table 2.

It seems the higher rates of smokers are among currently operational stationed aircrews (fighter, cargo, helicopter and engineer), against UPT's, controllers, paratroopers and physicians, all of then younger. The figures very clearly show the incidence among different categories. The highest rate are in operational units and pilots assigned at the Air Force Headquarter who currently fly for retraining. The reason for that is best explained by the results obtained by range of age. Figure 3 shows how incidence between 20 and 30 years are lower than the next decade in all groups but paratroopers, engineers and physicians, in transport there is almost no change. Those results means that the message and campaign against smoking habit

POPULATION	PERCENTAGE OF SMOKERS
SAF 1984	61%
SAF 1992	47%
Physicians in Cataloma 1987	57%
Physicians in Spain 1988	49%
Physicians in Andalusia 1987	60.5%
Physicians in Gomez USa Medical Center 1990	49.5%

Table 2 Smoking prevalence in Spain

has being followed mainly for the youngest aircrews, data very well demonstrated among cadets and advance pilots trainees.

Average rate of time since quit smoking is 5.8 years (range 7.5 - 4). That finding is very valuable if we correlate it with the time we started the campaign.

We observed as the survey conducted 8 years ago the prevalence rate of smoking habit among the flying population was even higher than the maximum rate detected in civilian population groups (12), which we tried to explain based on specific stressors, environmental and social conditions and insufficient health education.

Results of the present survey are consequence of both , repeated national campaigns since 1984, reinforced during the last 2 years adopting stronger public regulations (last one as an example to ban tobacco in domestic flights) and the flight medical community effort.

Epidemiologic studies have demonstrated respiratory function morbidity (17) or prevalence rates of cough and phlegm lower in subjects who do not smoke (18). Our results do not show a significant correlation between smokers and appearance of related symptoms. However, figures (number 4) shows an average of 24% in the 8 group categories, clearly associated their symptoms to their cigarette consumption. We can consider that almost a quarter of the smokers were concerned that their symptoms were secondary to the smoking and realize cigarettes harm the human body. This is a consideration which make those individuals the best candidates for future ex-smokers. Some authors estimate that 77% of the ex-

Fig.4. Relationship between smoking habit, years of smoking and related symptoms by group category.

		0 - 1000 HOURS	1001 - 2000 HOURS	2001 - 3000 HOURS	> 3000 HOURS
FIGHTERS	■	31	38	47	41,9
CARGO	□	67	73,9	44,4	36
HELICOPTERS	■	38,8	40,8	50	
ENGINEERS	▨	62	66	66,6	57

Fig 5. Relationship between smoking habit and flying time by group category.

smokers decided to quit because of selfawareness of personal harm (14,12).

Relationship between flying time and smoking is data that could be related to age, but we found significant correlation only in fighter pilots with 5000 and 6000 hours. These findings do not reflect the data derived from analysis of the but rather man demonstrate an additional stressor (flying high performance aircraft) that could effect smoking prevalence.

Any survey based in subjective data has a limited value, although it gives us a general idea about the actual situation of the aircrewmembers concerning this environmental hazard.

We have not investigated the possible prevalence of passive smokers and incidence of respiratory illness in those individuals chronically exposed to tobacco smoke in the work place. Presence of cotinine in urine has been demonstrated the best indicator of tobacco consuming and smoke inhalation, even more specific than determination of carbon monoxide in the expired air (25).

Respiratory functional evaluation, cotinine level, subjective related symptoms and smoking habit should be the major indicators of any epidemiological survey related with the impact, occurrence and risk estimation of tobacco exposure.

CONCLUSIONS

1. Our survey shows a decrease in the incidence of tobacco use in the Spanish Air Force in the last 8 years, a finding that we feel is directly related to the antismoking efforts of the aeromedical community.

2. Results of the survey also proved a very useful resource in giving actual, reliable and meaningful data about the current situation of tobacco use in the specific groups as well as the entire Spanish Air Force.

3. The role of the flight surgeon and staff at aeromedical facilities is obviously crucial in dealing with this environmental hazard.

4. In a future ideal world where an adequate non smoking population exist from which to draw aircrew candidates, a demonstrated smoking history or elevation of cotinine levels in urine could be a reason for rejection of applicants for flying duties.

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THE EFFECTS OF AN ANTIJET LAG DIET

Charles A. Salter 1 , Laurie S. Lester, Edward Hirsch
U.S. Army Natick Research, Development, & Engineering Center
Natick, MA 01760-5020
USA

Margaret Moline, Charles P. Pollak, Daniel R. Wagner
Institute of Chronobiology, Cornell Medical Center
White Plains, NY 10605-1596
USA

1. SUMMARY

The unpleasant symptoms surrounding jet lag or phase shifts (fatigue, insomnia, etc.) generally interfere with biological rhythms, performance, and subjective well being. A popular "jet lag diet" has been touted widely as an effective countermeasure to alleviate symptoms through systematic alternation of high (>3600 cal/day) and low (<800 cal/day) food intake, timed consumption of methyl xanthines, high protein breakfasts and lunches, and high carbohydrate dinners. Unfortunately, this system as a whole has never been adequately tested with humans. In the present study, 15 male subjects (aged 18-25) lived individually in time-isolation apartments for 15 consecutive days. For the first seven days they ate and slept according to their usual schedule. During the seventh night, they were phase advanced 6 hours, to simulate an easterly jet flight, and maintained their new schedules for 8 days. The eight control subjects consumed their normal diet throughout the study, while the seven diet group subjects consumed the "jet lag diet" prescribed by Charles Ehret. All subjects experienced jet lag as evidenced by disrupted sleep and body temperature ryhthms, mood and performance decrements, and lessened physical activity. The antijet lag diet did not lessen the severity of these symptoms and, in fact, worsened sleep. Although, the two groups did not differ with respect to sleep latency, duration, or composition before the simulated jet lag; afterwards subjects in the diet group slept on average 30 minutes less and were 31 percent less efficient than the control subjects. These results indicate that a popular antijet lag diet is not effective in young male subjects and may even worsen symptoms for aircrew members relying upon it.

2. INTRODUCTION

Jet lag is a well known and widely experienced malady among aviators who cross multiple time zones. The symptoms may include fatigue, insomnia during the new nighttime, sleepiness during the new daytime, and decrements in both performance and mood. These symptoms are thought to arise from the temporary dissociation among biological rhythms (e.g., the daily rhythm of core body temperature) that occurs when rapidly crossing time zones.

Adjustment to a new time zone is slow, often taking many days [1,2], and there is a directional asymmetry [3].

Adjusting to westbound travel is easier because it delays the sleep-wake cycle (i.e., stay up later and sleep later), which is in the direction of the natural tendency of the biological clock. Adjustment to eastbound travel is more difficult because the ability to advance the sleep-wake cycle is thought to be more limited.

Theoretically, the master timing system adjusts very quickly to a time zone shift [4]. However, even though the master clock sends out the appropriate internal timing signals for the various rhythms, their rates of readjustment vary. It is during the period of rhythm resynchronization that jet lag occurs. The ideal jet lag countermeasure then, would increase the rate of adjustment of the body rhythms to the new time zone.

While jet lag can be a debilitating annoyance to the civilian traveler, its effects on military aviators and other personnel arriving in a potentially hostile environment can be life threatening. Any countermeasure to jet lag that could improve the aviator's ability to perform optimally during the early stages of an overseas mission might confer a tremendous operational advantage. Early attempts to counter jet lag depended primarily upon common sense and self-observation [5,6], providing such suggestions as avoiding alcohol and drugs and forcing oneself to stick to the new schedule for meals and sleeping.

More recent theories have extrapolated laboratory data on discrete variables into a more comprehensive program which has never been tested as a whole. For instance, a special "jet lag diet" developed by Charles Ehret [7], of the Argonne National Laboratory, has received considerable popular acclaim but very little empirical testing. The diet is based on research indicating that food constituents can alter brain biochemistry and ultimately, behavior [8]. The diet prescribes consumption of particular foods at times that would facilitate appropriate kinds of behavior at the new destination. For example, the diet recommends that the traveler prepare for his trip by consuming high protein breakfasts for a specified number of days prior to departure, during the flight, and upon arrival. Dietary protein has been shown to increase levels of tyrosine found in the brain [9]. Tyrosine is a precursor to the neurotransmitters dopamine, norepinephrine, and epinephrine, and has been associated with alertness and increased resistance to stress [8,9,10]. The diet also recommends consuming high carbohydrate dinners in preparation for and during flight. Meals that are high in carbohydrate and low in protein have been shown to elevate brain levels of tryptophan, a precursor to the neurotransmitter serotonin [11,12]. Serotonin has been shown to hasten sleep onset [13,14].

The "jet lag diet" also makes use of the class of substances known as methylated xanthines that are found in coffee (caffeine) and in tea (theophylline). These substances have been shown to phase delay (i.e., reset to an earlier time) the body's biological clock if consumed late in the day [15]. Thus, consumption of coffee or tea at appropriate times and abstinence at inappropriate times could accelerate adjustment of biological rhythms to coincide with the new time zone.

3. METHOD

The research presented here describes the first comprehensive investigation of Ehret's dietary manipulation under the conditions of a highly controlled laboratory setting. A 6-hour easterly shift was simulated, since eastward travel requires greater adjustment of the body's biological clock and thus produces more severe jet lag symptoms than does westward travel. This provides a more rigorous test of the hypothesis.

3.1 SUBJECTS

Fifteen male Marines between 18 and 25 years of age participated in this study. Eight subjects were randomly assigned to the control group and the other seven were placed in the diet group. All subjects were screened to ensure that they were physically and psychologically healthy. Individuals taking medication on a regular basis, high caffeine users (i.e., more than two or three caffeinated beverages per day), and individuals who napped frequently or had an unusual sleep schedule (i.e., sleeping more/ less than 7-8 hours a night and retiring later than 0100) were not included in this study. Caffeine intake was prohibited during the baseline (except when prescribed for the diet group) so that the subjects would not be in a state of caffeine withdrawal during the study. Subjects were briefed minimally before they entered the study. They knew that they were participating in jet lag research, and that at some point in the study, their schedule would be altered in some way. They were not told the direction of the time zone shift (east), the magnitude of the shift (6 hours), or the day the shift would occur.

3.2 DEPENDENT MEASURES

Data from a large number of dependent measures were collected in this study. This paper reports representative examples of the measures used and data collected with regard to variables of the greatest potential interest to aviators. These include sleep efficiency, core body temperature, cognitive performance, alertness, and mood (see Moline et al. [16] for a complete report).

3.2.1 SLEEP EFFICIENCY

Brain activity was recorded during the sleep period. Sleep stages were determined by experienced scorers using standard methods [17]. The following parameters were assessed:

> Total sleep time
> Sleep efficiency
> Sleep latency
> Slow wave (deep) sleep
> Slow wave sleep latency
> REM latency

3.2.2 CORE BODY TEMPERATURE

Body temperature was measured every minute from a rectal thermometer worn by each subject. The accuracy of the measurements is + / - 0.1 °C (and then converted to °F). Subjects did not report any difficulty with the probe, and

were able to exercise without discomfort. The temperature rhythms obtained by plotting these data were examined with regard to phase and amplitude changes that occurred over the course of the study. Phase refers to the position of the daily maximum/minimum temperature relative to the sleep/ wake period. Amplitude refers to the number of degrees between the daily minimum and maximum temperatures.

3.2.3 VERBAL REASONING TASK (VRT)

The VRT was one of the tasks used to assess cognitive performance. This complex verbal reasoning task is a modified form of the Baddeley Reasoning Test [18]. The task is composed of a set of 32 sentences, each of which is followed by a letter pair consisting of the letters "M" and "C." The subject is required to decide whether the sentence accurately describes the letter pair. For example:

$$\text{M IS NOT PRECEDED BY C - MC}$$
$$\text{response: true}$$

Latency to respond and accuracy were recorded. The VRT was administered on a computer 5-8 times a day, including once upon waking, once before each meal or snack, and once before sleep.

3.2.4 MEMORY AND SEARCH TASK

The memory and search task (MAST) is an immediate processing visual search task [19]. Individuals were issued hand-held Sharp microcomputers on which the MAST had been programmed. When performing the task, the subject turned on the machine, entered a subject identification number, and followed the prompts to begin the task. Once the MAST began, a string of 16 letters was shown on the left side of the display and a short "target" string of 2, 4, or 6 letters was shown simultaneously on the right side of the display. The subject had to decide if all of the letters contained in the target appeared in the longer string, in any order. The subject was instructed to respond as quickly and as accurately as possible, using the labeled "yes" and "no" response keys on the computer. Memory load was varied by changing the length of the target string. While the 16 character response string changed after each response, the same 2, 4, or 6 character target appeared during the 2 minutes that the subject spent at that memory load level. Order of presentation of the 2, 4, or 6 memory load levels was randomized. Thus, the subject spent approximately 6 minutes on the MAST each time the task was performed. The MAST was taken as frequently as the VRT: about 5-8 times a day.

3.2.5 VISUAL SEARCH TASK

The visual search task has been used in a number of different circadian rhythm studies, and its circadian rhythm normally is parallel to that for body temperature [20]. In other words, alertness tends to be higher when core temperature is rising. The subject was presented with a line of 30 random upper-case letters of the alphabet. He was required to scan through the line from left to right searching for an occurrence of the letter "E." The "yes" or "no" button then was pressed to indicate whether or not an E was found. Thirty-two trials were given at each session with half having no E present. For each individual trial, the latency from the onset of the display to the initiation of a response was recorded to the nearest 10 msec by the computer. The accuracy of this response also was recorded. The visual search task was performed as often as the MAST and the VRT tasks.

3.2.6 ALERTNESS AND MOOD

Changes in self-reported alertness and mood were measured by asking the subject to complete nine questions. The subject was asked to indicate how alert, sad, tense, motivated, happy, weary, calm, and sleepy he was feeling at the moment. He also was asked how he was feeling overall. The subject responded by moving the cursor on a computer screen along a line anchored at one end by "very little" and at the other end by "very much" (visual analog scales), or by other appropriate endpoints. Measures of alertness and mood were taken in conjunction with the measures of cognitive performance.

3.3 PROCEDURE

The 15 male Marines lived in individual, time-isolation apartments for 15 consecutive days (i.e., with no sun exposure and no contact with the media or outside world other than the laboratory staff). Prior to the shift, subjects slept according to their individual routine schedules. They had normal interior artificial lights during the wake cycle and all lights out during the sleep cycle. A 6-hour easterly time zone shift was simulated by advancing each subject's time of awakening by 6 hours on the seventh night and by maintaining his daily routine on the new time for the remainder of the study. Subjects in the control group were maintained on a mixed nutrient, balanced diet. Subjects in the diet group were put on Ehret's popularized "jet lag diet" [7] on day 4, prior to the shift (day 7).

The diet regimen consisted of alternating days of feasting (days 4, 6, and 8) and fasting (days 5 and 7) with consumption of high protein breakfasts and lunches, high carbohydrate dinners, and scheduled consumption of caffeinated beverages. During the feasting days, subjects were encouraged to consume as much as possible with an aim towards an intake of 3600 kcal or more. The feasting and fasting meal plans are summarized on Table 1.

TABLE 1.

Ehret's diet plans

Feasting meal plan

Breakfast:	Plenty of steak or other meat, cheese, and eggs As much milk as wanted 1/2 cup orange juice
Lunch:	Plenty of assorted cold cuts and cheese As much milk as wanted 1 slice of bread, buttered 1 cup of vegetables 1 apple, pear, or bunch of grapes
Dinner:	Plenty of pasta with meatless sauce As much bread as wanted, lightly buttered Fruit or fruit salad, as much as wanted Cake and/or cookies Soda (noncaffeinated)
Snack:	Cake, cookies, etc.

On feasting days, subjects were served meals that were aimed at an ideal of 3600 kcal or more.

Limited meal plan

Breakfast:	2 eggs with butter (tbsp), or 2 oz. of cheese or combination (1 egg and 1 oz. cheese)
Lunch:	3 eggs or 3 oz. of cheese or meat or some combination 1 cup raw vegetables or 1/2 cup cooked (several vegetables were unlimited, e.g. lettuce)
Dinner:	1 egg or 1 oz. of cheese or meat 1 tbsp butter or margarine 1 fruit exchange* 1 bread or pasta exchange* 2 1/3 cups raw vegetables or 1 1/4 cups cooked vegetables 1/4 cup milk

* "Exchange" refers to equicaloric amounts within a food group using the nutrition handbook for diabetics as a reference [27].

On calorie limited days, subjects were served meals that were aimed at an ideal of 800 kcal.

At dinner on the day before the shift occurred (day 7), a subject in the diet group was to consume one to two cups of coffee or strong black tea. Ideally, each subject would have had two cups, but some subjects chose not to consume the larger quantity.

During the preparation of each meal, a detailed description of the meal contents was made by the technician on duty. Each food item and beverage was weighed or measured before it was given to the subject. Meats or fish that were cooked were weighed after cooking. The technician also weighed or measured any leftover items and recorded the information. Macronutrient information was estimated from the records of the diet group of subjects by referring to a manual published by the United States Department of Agriculture [21]. Total kcal, protein, fat, and carbohydrate content were calculated for each component of the meal.

3.4 MEAL COMPOSITION IN THE DIET GROUP

The 2 days before the countermeasure began (day 2 and 3) were designated normal eating days (i.e., days with free choice of food types and kilocalories). Days 4, 6, and 8 were feast days, when the subjects were instructed to try to achieve a high caloric intake, but when the type of foods was limited to obtain a particular macronutrient composition (high protein or carbohydrate). Days 5 and 7 were calorie-limited days, when not only were the kilocalories lower, but the choice of foods also was predetermined (as detailed in the Procedure section above).

Actual consumption of the diet group subjects was calculated to determine how well they adhered to the diet plan. Total kilocalories and grams of protein, fat, and carbohydrate were first calculated for each component of a meal. These were summed to obtain the meal totals. Means of

breakfasts, lunches, dinners, and snacks from "regular" (pre-countermeasure) days, from the feast days, and from the calorie limited days then were determined. The same technique also was used to determine the average macronutrient content of the meals in the two example "fast days" provided by Ehret in his book [7; p. 149]. This could not be done for the "feast days," since Ehret includes instructions to eat "plenty of...; as much milk as you like; lots of meat...," etc. [7; p. 150], and thus it was impossible to estimate the composition in the same ways as for the "fast days." The data are listed on Table 2; "fast day" refers to our analysis of Ehret's sample diets.

As can be seen from Table 2, the composition of the meals differed depending on the type of day. The subjects apparently were not able to increase their caloric intake on the feast days. On calorie-limited days, total caloric intake dropped to 32 percent of either the feast or regular days. The mean kilocalories ingested on the calorie-limited days by the subjects was 1032, above the ideal of 800 proposed by Ehret [7]. However, as can be seen from the "fast day" data, Ehret's suggested meal plans also exceed his ideal.

The jet lag diet book [7] did not state that one must eat more than usual on the feast days. Rather, high caloric intake is required. The subjects already were consuming large quantities of food. The ratio of carbohydrate to protein differed between the regular days and feasting days in the required directions. During the feast and calorie-limited days, the ratios changed depending on the meal. Subjects ate more protein during breakfast and lunch. During dinners, more carbohydrate than protein was consumed. Although the ratio is not different between the regular and calorie limited days for dinners, it is important to remember that the subjects still were eating a high carbohydrate dinner (three times more carbohydrate than protein was consumed). The data presented in Table 3 support the view that

TABLE 2.

Macronutrient composition of meals in the diet group

Meal	Day type	kcal	Prot(g)	Fat(g)	Carb(g)
Breakfast	Regular	1012.6	37.9	49.1	107.3
	Feast	1027.9	70.3	67.2	36.3
	Limited	219.9	13.2	18.7	2.2
	Fast	258.7	17.6	16.8	11.6
Lunch	Regular	993.8	52.4	48.5	103.8
	Feast	909.4	60.1	45.4	66.0
	Limited	325.3	27.0	18.5	16.9
	Fast	275.5	36.8	8.6	10.2
Dinner	Regular	900.9	40.0	27.9	127.3
	Feast	486.2	22.9	16.0	195.8
	Limited	442.4	19.8	16.1	61.3
	Fast	411.5	7.9	9.4	85.0
Snack	Regular	335.2	9.8	12.3	51.0
	Feast	303.8	6.3	11.8	44.2
	Limited	44.6	0.9	0.9	8.3
	Fast	--------	--------	--------	--------
Total	Regular	3242.4	140.0	137.6	389.3
	Feast	3227.3	159.6	140.5	342.3
	Limited	1032.1	60.8	54.2	88.6
	Fast	945.7	82.7	34.8	106.8

TABLE 3.
Ratio of carbohydrate to protein intake in the diet group

Meal	Day type	Ratio (Carb[g]/Prot[g])
Breakfast	Regular	2.8
	Feast	0.5
	Limited	0.2
	Fast	0.7
Lunch	Regular	2.0
	Feast	1.1
	Limited	0.6
	Fast	0.3
Dinner	Regular	3.2
	Feast	8.6
	Limited	3.1
	Fast	10.8
Snack	Regular	5.2
	Feast	7.0
	Limited	9.2
	Fast	--------

the subjects were able to comply with the macronutrient specifications of the diet plan.

4. RESULTS
The measured biorhythms generally were altered in several ways by the simulated jet lag.

4.1 TEMPERATURE RHYTHMS
When compared to the baseline, there were general differences in both the phase and amplitude of body temperature rhythms after the shift. The core temperature rhythm is made up of two components: (1) an endogenous component whose pattern is timed (driven) by the biological clock, and (2) an exogenous or evoked component that is due to the events of daily living such as sleeping and exercising. Each of these components contributes approximately half of the measured amplitude (number of degrees between the peak and trough of the rhythm each day).

When a subject is entrained, the exogenous influences and the endogenous components are in phase. This means that the decrease in temperature evoked by sleeping per se and the decrease in temperature determined by the biological timing system occur around the same time, leading to a sharp drop in temperature at sleep onset and to the temperature minimum around midsleep. During the waking interval, the influence of activity and the higher endogenous component lead to the afternoon maximum in temperature. If the two components are no longer in phase for any reason, then the temperature amplitude will be less. For example, the sleep-evoked drop in temperature could occur at a phase of rising temperature driven by the biological clock. In this example, the measured temperature rhythm would be much flatter than when the components are in phase.

If the core temperature pattern could adjust instantaneously following the simulated jet lag, then the two components would remain in phase. However, this was not the case. As a result, all subjects showed a reduction in amplitude and gradual phase readjustment. All groups showed an initial

mean decrease in temperature amplitude of between 0.2 and 0.5 °F on the first day following the shift. The diet group reached its smallest amplitude on the second day after the shift, and the control group reached its smallest amplitude on the third day after the shift. Thereafter, the amplitude in both groups returned (increased) toward the baseline.

There were two components to the phase shift: (1) an initial rapid shift, and (2) a more gradual change toward complete resynchronization. Subjects in each group shifted between 2.5-4.5 hours during the first day. This large change in phase is due in large part to the sleep-evoked component of the temperature rhythm that now occurred 6 hours earlier. Thereafter, subjects in the control and the diet groups advanced slowly, so that even 7 days after the shift, they were still about 1 hour later than the phase position on the baseline. Thus, more time than allowed in this study would be required for complete resynchronization.

4.2 MEMORY AND SEARCH TASK (MAST)
MAST data were analyzed according to signal detection theory. A value, d-prime, was calculated for each subject. D-prime is an indication of the overall accuracy of a subject (d-prime = (mean of correct responses - mean of errors) / the standard deviation). In other words, it adjusts the number of correct answers with a correction for the false alarm rate (the tendency for a subject to answer when there has not been a signal presented). There were no group differences or shift effects on the subjects' d-prime scores.

A repeated measures MANOVA (Multiple ANalysis Of VAriance) then was used to examine the number completed, number of hits, number of misses, number of false alarms, and number of correct rejections. In the two-character test, there were significant condition (baseline vs. postshift) and condition by group effects ($p < 0.02$ and 0.03, respectively). However, the main condition effect can be attributed to practice since learning continued from baseline through the post-shift interval. The condition by group interaction appears to be due to the relative lack of a learning curve in

the diet group after the shift. In a related study [22], Marines deploying from the U.S. to Norway by air performed the MAST before, during, and after the flight, for a period of 16 days. Their performance generally improved throughout the period, except for a slight decrease the day after time shift.

4.3 VERBAL REASONING TASK (VRT)
This performance measure showed significant effects of learning ($p < 0.01$), except that both groups performed slower (but not less accurately) on the days immediately following the shift. It appeared that the subjects preferred to be correct, and increased the time taken to ensure that the percent correct was as high as usual. Inter-group differences were not evident.

4.4 VISUAL SEARCH TASK (VST)
Subjects performed this task more quickly as the study progressed, thus indicating learning. However, subjects required more time than predicted from the learning curve to perform this task on the 2 days following the phase shift. It appears that the subjects slowed down in order to maintain a desired level of accuracy.

4.5 EXERCISE
During the study, subjects were permitted to exercise for up to 45 minutes on each of two occasions during the day. One exercise period was scheduled before lunch and the other before dinner. The duration and type of exercise were under the subjects' control. Many used exercise bicycles, treadmills, or performed calisthenics. There were no significant differences between the subject groups. However, when all subjects were compared, there was a significant condition effect (Table 4), as determined by a repeated measures analysis of variance.

TABLE 4.

Baseline	16.2 min
Postshift	12.9 min

This data indicate that the subjects exercised significantly longer during the baseline than following the shift ($p < 0.02$). This finding is interesting since it correlates with the decrease in the feeling of well-being that was reported by the subjects. Thus, deciding whether or not to exercise and for how long may be a useful indicator of a feeling of malaise that often is reported to accompany jet lag.

4.6 SLEEP PARAMETERS

4.6.1 TOTAL SLEEP TIME
Total sleep time (TST) is defined as the number of minutes that a subject spent sleeping during the in-bed interval (see Figure 1). There was no difference between the control and the diet groups during the first six nights. However, on night 7, subjects in the diet group slept at least 30 minutes less than the subjects in the control group ($p < 0.05$). This was due most likely to the scheduled caffeine consumption at dinner preceding the sleep episode on day 7. On successive nights thereafter (nights 9 to 15), mean TST remained below the preshift mean in each group. Thus, more than eight sleep periods would be required for the subjects to resume their previous duration of sleep.

4.6.2 SLEEP EFFICIENCY
Sleep efficiency (SE) is defined as the percentage of time in bed spent actually sleeping. Subjects in each group slept well before the simulated jet lag, as presented in Figure 2. However, on night 7, SE was low in the diet group (50.2 percent), 40 percent lower than during the baseline and 31 percent less than the control group. This magnitude of decrease was not observed in the control group (11 percent). It is probable that the caffeine intake contributed to the low SE on night 7. The decrease in SE in the diet group on that night can be explained in large part by an increase in the sleep latency (see Figure 3). The alternating pattern of sleep efficiency after the shift represents a "competition" between the need of a subject to sleep, and the tendency to be alert during the new phase of the day when sleep was scheduled.

4.6.3 SLEEP LATENCY
Sleep latency (SL) is defined as the time taken to fall asleep once the lights were turned off. The SL times are depicted in Figure 3. During the baseline period, subjects took between 11 to 14 minutes to fall asleep. On day 5, the mean SL in the diet group was somewhat greater than during the 3 previous days (20 vs 11 min). This increase may be due to the effects of caloric restriction, which can interrupt sleep patterns [23,24]. The longer latency on day 7 was found more consistently and represents the effect of caloric restriction and caffeine consumption.

4.6.4 SLOW WAVE SLEEP
Slow wave sleep (SWS), also known as deep or restorative sleep, is known to increase after sleep deprivation. During the baseline preshift period, mean SWS for the two groups did not differ (Figure 4). On night 7, the number of minutes of SWS was lower than baseline in each group. The diet group had half as much SWS as the control subjects. This may again be due to the caloric restriction and caffeine. Since sleep latency had increased on night 7, there was less time available for any stage of sleep.

4.6.5 PERCENTAGE OF SLOW WAVE SLEEP
Percentage of slow wave sleep (%SWS) is the percent of TST spent in SWS (see Figure 5). During the baseline, each group averaged 27 percent of the total sleep time in SWS. After the shift, %SWS remained slightly elevated in each group for the duration of the study. Since the number of minutes of SWS was not greater during those days, the increase in %SWS can be explained by the decrease in TST (%SWS = min SWS / TST).

4.6.6 LATENCY TO SLOW WAVE SLEEP
Latency to slow wave sleep (Figure 6) is the amount of time that it takes to enter the SWS period. As can be observed, the latency was longer in the diet group on night 7, the sleep following the caffeine consumption and calorie-limited day. Therefore, some of the decrease in minutes of SWS on night 7 can be accounted for by the increase in SWS latency.

On night 8, SWS latency tended to be shorter, reflecting the physiological need for SWS following sleep deprivation. During sleep episodes thereafter, the latencies were near the baseline values except for the last night (night 15) in the control group. Possibly excitement from anticipating the end of the study contributed to this increased latency.

4.6.7 REM LATENCY
REM latency, the time between falling asleep and the onset of REM sleep, differed before and after the shift (Figure 7). During the baseline, REM latency tended to be shorter than would have been predicted for this age group (80-90 min). After the shift, REM latency tended to shorten (Figure 8).

This effect was seen most persistently in the diet group. The shortening of REM latency is difficult to explain based on previous research. However, it is possible that the shorter REM latency reflects the physiological need for REM sleep following sleep deprivation.

4.7 ALERTNESS

The subject's alertness was assessed 6-8 times a day, concurrently with the other measures of affective state. As can be seen in Figure 9, both groups experienced a severe drop (at least 10 percent) in alertness on the first day after the shift (day 8). The percent change of alertness for both groups increased thereafter and, with the exception of the fifth day after the shift (day 12), the percent change for the control group was consistenly higher than for the diet group.

5. CONCLUSIONS

Several conclusions can be drawn from this first comprehensive empirical test of a commonly proposed countermeasure, Ehret's "jet lag" diet [7].

5.1 JET LAG OCCURED IN THIS POPULATION OF SUBJECTS.

These young, fit military subjects were susceptible to many of the common symptoms of jet lag. Their core body temperature, alertness, and performance changed. They performed less quickly, although not necessarily less accurately, on the measures of cognitive performance (reduced speed, even if accuracy is maintained, could prove fatal to a pilot in combat). Much of this performance decrement has to do with sleep deprivation and was expected. Subjects did not exercise as long after the shift. Since exercise is the one event of daily living recorded here that is solely up to the subject as to duration and type, its reduction is an indication that the subjects felt worse after the shift than before.

5.2 THE JET LAG DIET DID NOT HELP.

The diet plan did not improve sleep (see point #3 below), increase the rate of resynchronization of the temperature rhythm, or improve mood or performance after jet lag was introduced. Therefore, the jet lag diet should not be promoted as a useful countermeasure.

5.3 THE RECOMMENDED CAFFEINE COMSUMPTION IMPARED SHIFT ADJUSTMENT.

One of the key features of the jet lag diet program is the timed consumption of caffeine. While feasting and calorie restriction did not change sleep parameters, caffeine intake did. On the night following the caffeine intake at dinner, subjects required more time to reach deep sleep, and had fewer minutes of deep, restorative sleep. Thus, despite the claim that high carbohydrate consumption can induce sleep, this effect (if real) is overshadowed by the disruption of normal sleep by caffeine consumption.

5.4 FUTURE RESEARCH.

Future research should be directed at determining whether other dietary patterns can alleviate jet lag and if so, whether aviators can be induced voluntarily to alter their dietary patterns in desirable ways. For example, high carbohydrate dinners may help foster sleep in the absence of caffeine consumption. But, aviators often don't follow standard dietary recommendations, even though inadequate food intake among pilots has been linked to aviation mishaps [25]. Future research could also examine other types and patterns of countermeasures. For example, a recent study [26] found that phase reversals to night work and day sleeping were facilitated by blocking sunlight, maintaining quiet during sleep time, and regulating meal schedules regardless of content.

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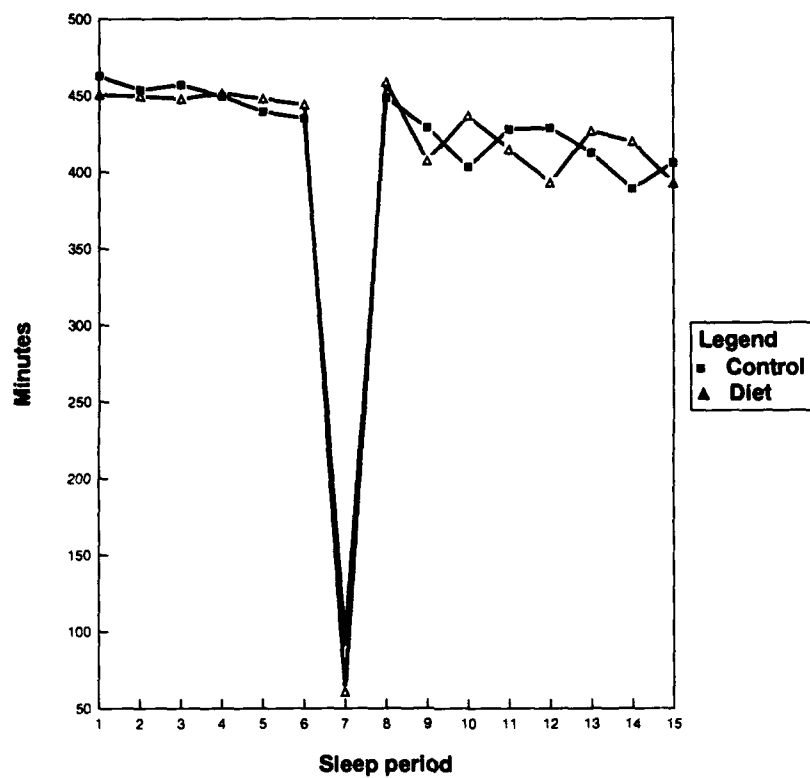
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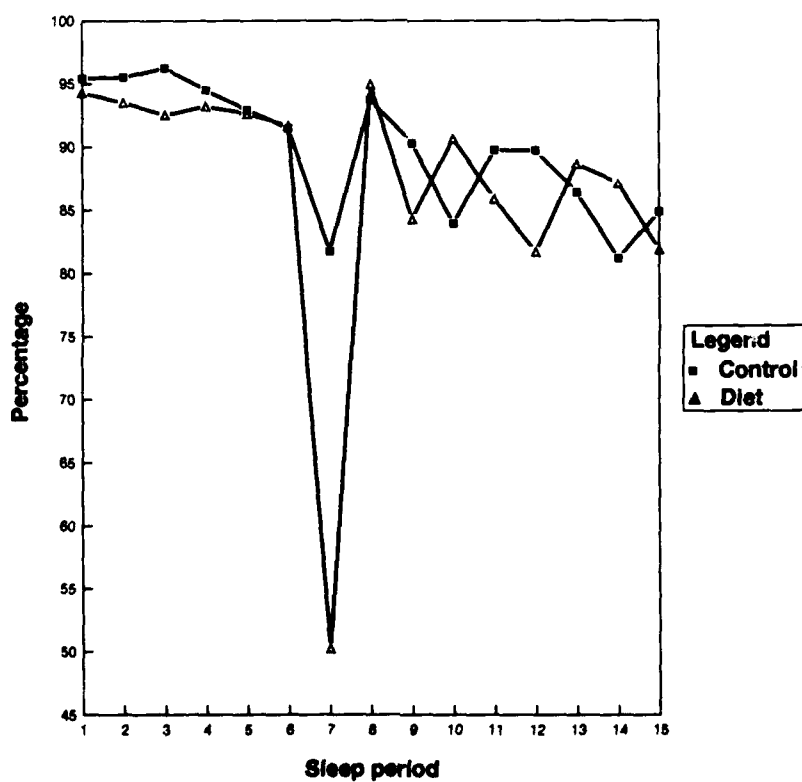
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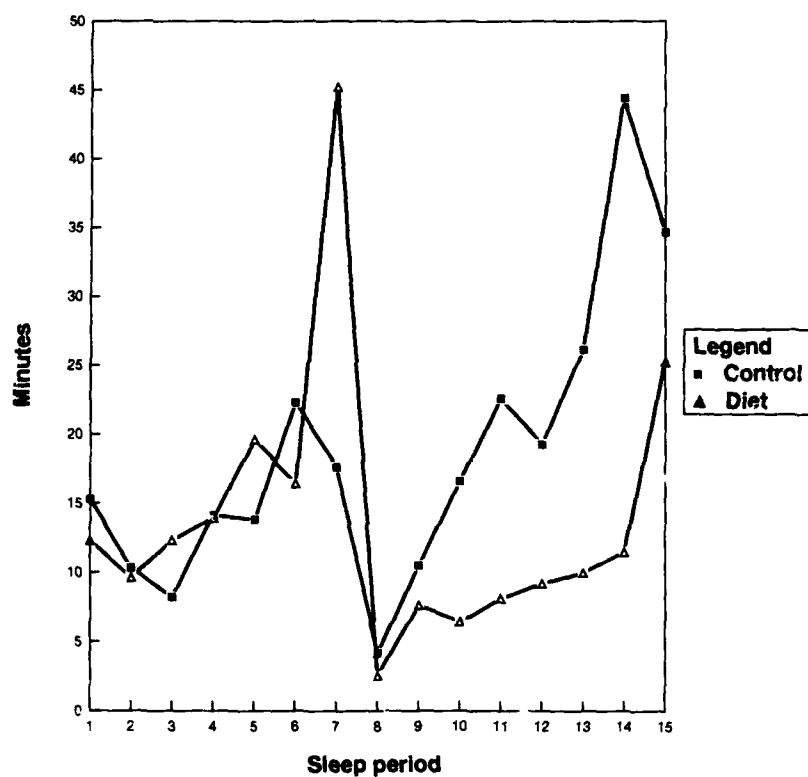
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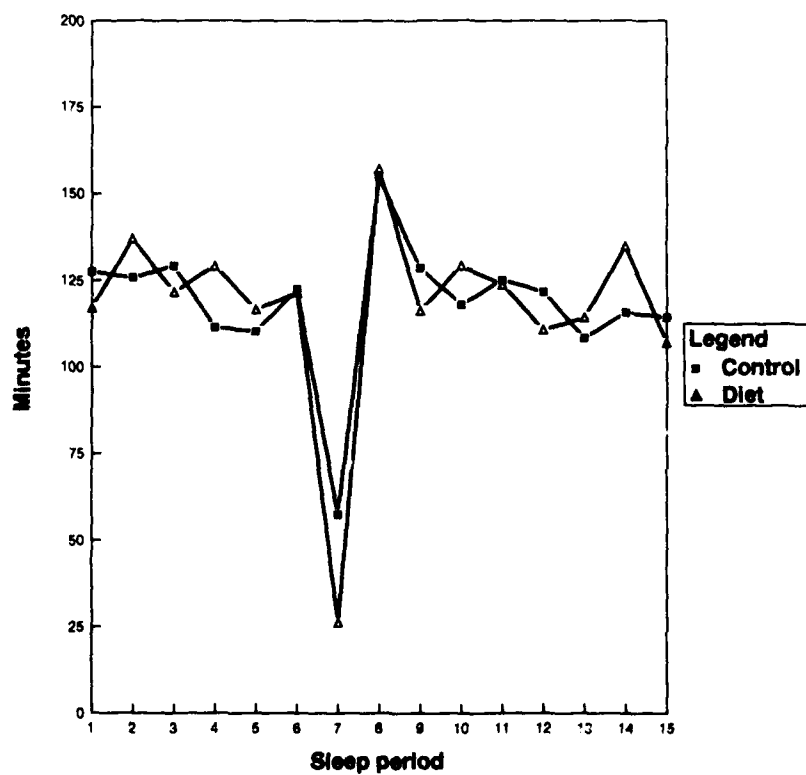
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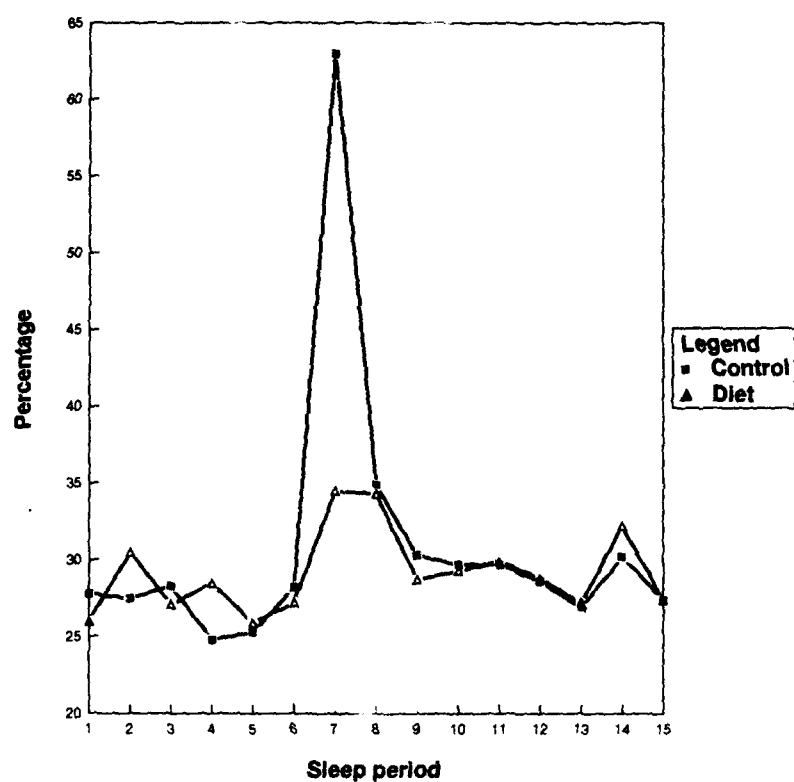
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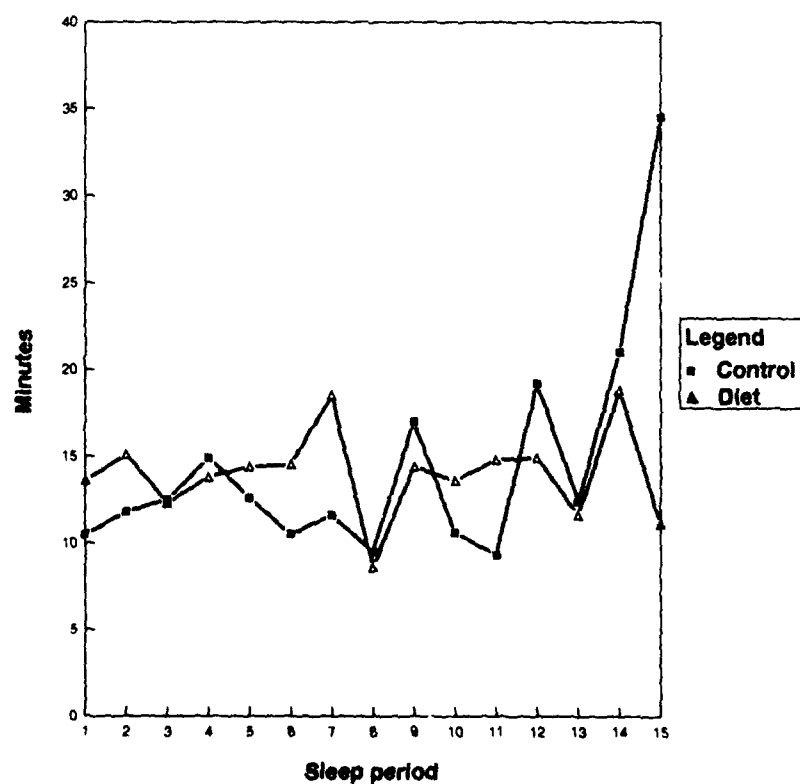
Figure 6. Latency to slow wave sleep.
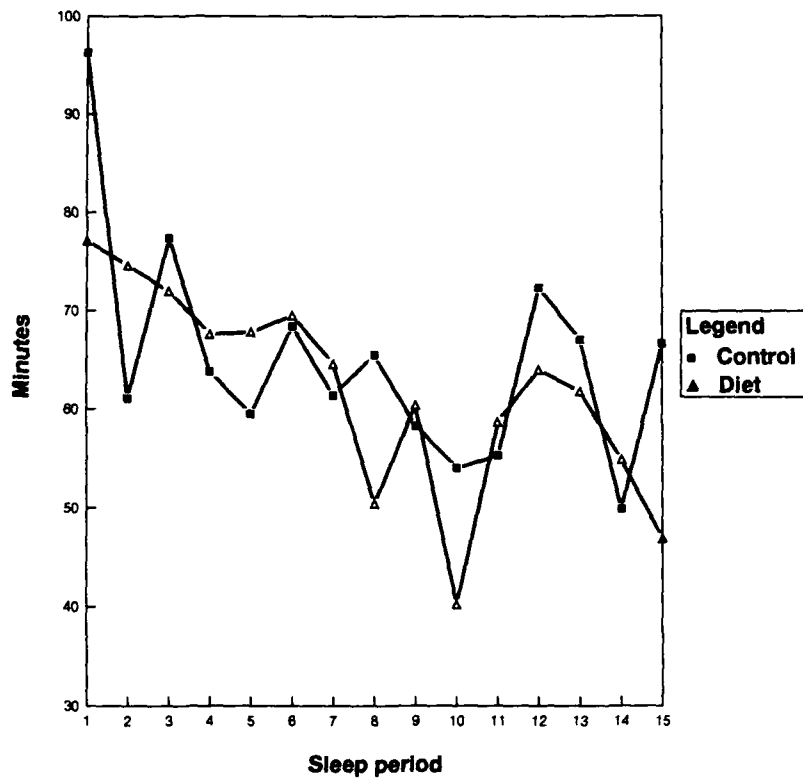
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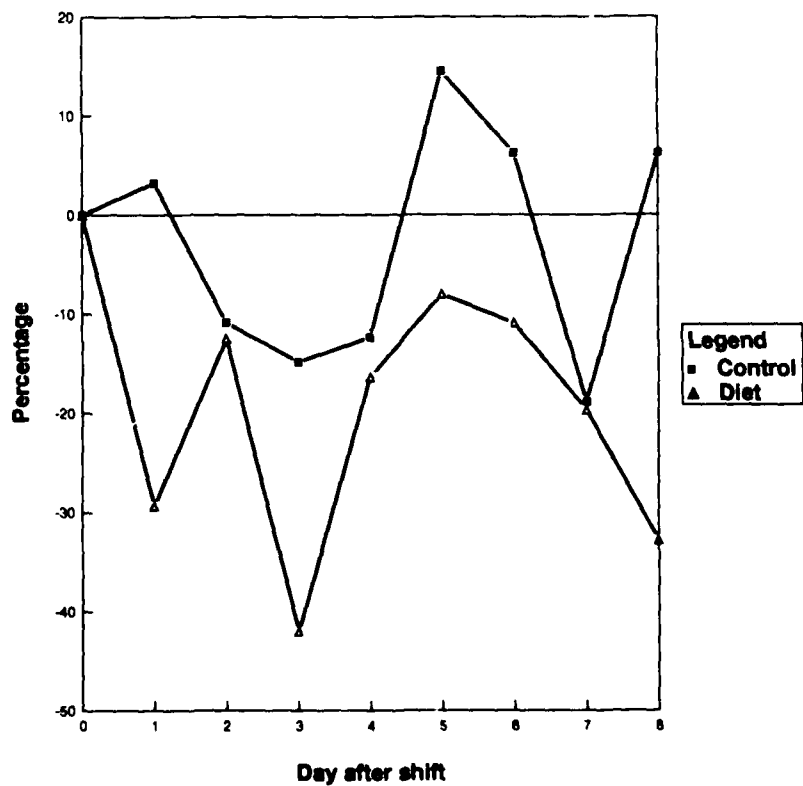
Figure 8. Percent change in latency to REM sleep.
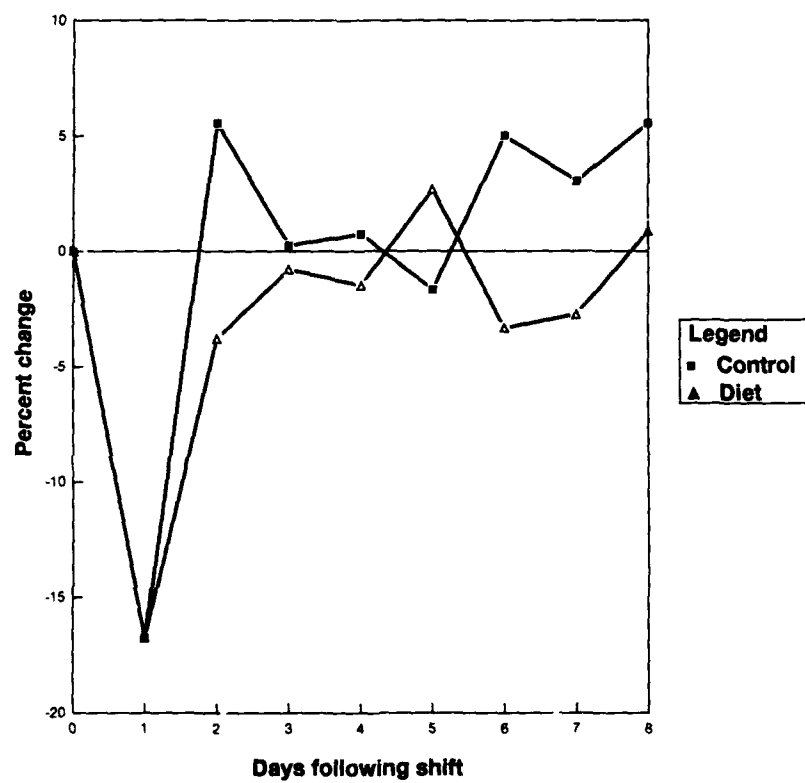
Figure 9. Percent change in rating of alertness.

SUBJECTIVE MOOD AND FATIGUE OF C-141 CREW DURING DESERT STORM.

Jonathan French
Patricia A. Boll
Roger U. Bisson
Kelly J. Neville
William F. Storm
Stephen H. Armstrong
Timothy Slater
Robert L. McDaniel[1]

Sustained Operations Branch
Armstrong Labs/CFTO
Brooks AFB, TX USA 78235-5000

[1]437 Military Airlift Wing
Charleston Air Force Base South Carolina, USA 29404

SUMMARY

Profile of Mood States (POMS) data were used to assess the subjective condition of C-141B aircrew members during Operation Desert Storm (March/April, 1992). The POMS dimensions used were anger, fatigue, vigor, tension, depression and confusion. Data were collected during 2 intervals of the MAC crew duty day; legal for alert (LFA) and crew rest (CR) intervals. The POMS dimensions correlated with one another during the 30-day study. Fatigue, vigor and confusion were different between LFA and CR suggesting that the CR interval was restorative. During both LFA and CR intervals, cumulative flight hour blocks from 0-75, 76-100, 101-125 and 126-150 hours per month revealed no significant effects on subjective mood states. However, mood was sensitive to conditions of recent (1-2 days) flight hours and sleep hours in combination with cumulative flight hours per 30-days. In particular, when cumulative flight hours exceeded 125 hours per 30-day period, the vigor dimension was affected by the amount of sleep and flight hours in the most recent 24-48 period. Therefore, attending to recent sleep and flight hours as well as cumulative flight hours per 30-day interval may reduce fatigue and improve mood when operational pressures require exceeding the normal 125 flight hours per 30-days.

1 INTRODUCTION

During Desert Storm, the coalition forces allied against the invading army of Iraq depended on a 6,000 mile air bridge created by the USAF Military Airlift Command (MAC) for food and supplies. MAC had to increase the number of supply missions from the US to bases in Saudi Arabia in order to meet the demand. This required extending the maximum crew flight time of 125 cumulative flight hours to 150 cumulative flight hours per 30-days. MAC was concerned with the impact of continuous, long duration missions on flight safety. There could be multiple stressors associated with the accelerated pace of MAC flights during Desert Storm. For example, increased sleep disturbances have been associated with cumulative, long distance missions (1). Previous research has also suggested that irregular rest and activity cycles can deteriorate performance in aircrew members (2). As well, continuous, long endurance flights are known to have detrimental physiological consequences (3,4). Finally, eastward flight, which MAC crews routinely flew, produces more sleep disruption than westward trips (5). Armstrong Laboratory (AL/CFTO) has experience in evaluating mission induced fatigue. Accordingly, MAC requested that investigators from CFTO evaluate the effects of 150 flight hours on mood, sleep and perfor-

mance in a 30-day period with minimum allowable crew rest (12 hours) during the final days of Operation Desert Storm.

2 METHODS

Five C-141B crews were selected by MAC to participate in the study during the final week of Desert Storm and 3 weeks beyond (16 March - 14 April, 1991). The crews were selected from the 437th Military Airlift Wing, Charleston AFB, NC and were authorized for extended cumulative flight of 150 hours per 30-day period and minimum allowable crew rest periods of 12 hours per day for the duration of the 30-day exercise. One investigator from the Sustained Operations Branch of Armstrong Laboratory accompanied each of the crews throughout the data collection period. Crews completed an activity log designed for the study which contained a record of half hour events selected from a list of pertinent activities (landings, sleep, meals, etc) as well as oral temperature and fatigue ratings, location, and quality of sleep. These procedures are described more thoroughly in Boll, et al, 1992 (6).

Other papers presented at this symposium attend to the impact of fatigue on performance, sleep and nutrition (6,7,8).
This report describes the profile of mood survey (POMS) results that were used to evaluate aircrew subjective mood during the 30-day field study. POMS were taken when the crews were legal for alert (LFA); that is immediately prior to the start of their duty day and at the start of the crew-rest interval (CR); that is at the end of their duty day. POMS is a convenient method of identifying and assessing fluctuating, affective mood states (9). It identifies six mood dimensions: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment (10). Responses to the 65 adjectives on the POMS consists of selecting one qualification from a five point scale which ranges from 'not at all' to 'extremely'. The standard POMS data are normalized to college level samples, as is the typical procedure for non-psychiatric populations, in order to produce symmetrical scores. Responses were anchored to what the individuals were experiencing at the time the POMS were taken. The minimum and maximum values possible for each dimension using these scoring procedures are shown in Table 1.

Table 1. Minimum and maximum scores on POMS for each of the Dimensions evaluated.

	Minimum	Maximum
Fatigue	34	77
Confusion	37	73
Tension	37	76
Vigor	26	76
Anger	37	101
Depression	37	91

Data analysis focused on pilots only (aircraft commander and co-pilot) since they slept less during flight than other crewmembers. Other crew, the engineers and the loadmasters, were able to sleep in shifts or sleep throughout the duration of the flight, respectively, and were not considered in the analyses.

3 RESULTS

The average POMS dimensions were correlated (p < 0.01) with one another during LFA and CR with the exception of Tension and vigor (r = -0.18). These results are shown in Table 2. The shaded area of Table 1 represents the correlation matrix for LFA and the unshaded area represents the same for the CR interval (N=171 observations). In general, the largest correlations were found for the CR interval. Large correlations between anger and depression dimensions as well as fatigue and vigor dimensions were common to LFA and CR intervals.

Analysis of variance designs were used to compare POMS dimensions. POMS results were improved (p < 0.01) for LFA compared to CR for fatigue, vigor and confusion but

not for anger, tension or depression. These results are shown in Figure 1. The largest differences shown in Figure 1 are for fatigue and vigor.

Cumulative flight hours in a 30-day period were organized into cumulative flight hour blocks. The blocks used were 0-75 hrs, 76-100 hrs, 101-125 hrs and 126-150 hrs. Analyses focused on changes across flight hour blocks for each of the POMS dimensions as crews approached the maximum number of flight hours. During both the LFA and CR intervals, cumulative flight hour blocks alone had no significant relationship with subjective mood dimensions.

Evaluation of the POMS data next centered on more recent events in the pilots activity logs. Specifically, recent flight hours and recent sleep hours were evaluated over periods of 24 and 48 hours. This evaluation revealed effects on some of the POMS dimensions when combined with cumulative flight hour blocks. These results are shown in Table 3. Specifically, the depression and tension POMS dimensions were increased during LFA when flight hours in the most recent 48 hours increased after cumulative flight hours in a 30-day period of < 75 hours and 100-125 hours, respectively, as shown in Table 3. As well, when cumulative flight hours exceeded 125 hours, the POMS vigor dimension was related to the amount of sleep in the past 48 hours for the LFA and the CR intervals. Vigor was also related to the amount of flight in 48 hours for the CR interval as shown in Table 3.

Cumulative flight hours, recent flight and sleep hours and other activity log parameters associated with the largest POMS fatigue scores are shown in Table 4 for the overall and the LFA and CR intervals. The average POMS fatigue score across the entire 30-day exercise and the associated parameters are shown in column 1 of Table 4 under the Mean (Total) column. Similar scores for the average maximum POMS values found during the LFA and the CR are shown in Column 2 and 3 of Table 4, Mean (LFA) and Mean (CR), respectively. The time value in Table 4 refers to the average time (Zulu time) the POMS fatigue scores were obtained. Thus, the maximum POMS value for LFA (57.0) and CR (61.3) was found at 1015 and 1050 hours respectively, after 62.9 and 88.9 cumulative flight hours in a 30-day period.

4 DISCUSSION

The correlations between POMS dimensions suggested that most mood states demonstrated consistant changes over the 30-days.

Table 2. Correlation coefficients for POMS dimensions for LFA (SHADED) and for CR over the 30-day study.

	ANGER	FATIGUE	VIGOR	TENSION	DEPRESSION	CONFUSION
ANGER	-	0.20	-0.29	0.40	0.58	0.37
FATIGUE	0.31	-	-0.57	0.28	0.34	0.59
VIGOR	-0.29	-0.68	-	-0.18	-0.27	0.59
TENSION	0.73	0.32	-0.30	-	0.52	0.45
DEPRESSION	0.81	0.36	-0.36	0.64	-	0.53
CONFUSION	0.60	0.63	0.57	0.59	0.66	-
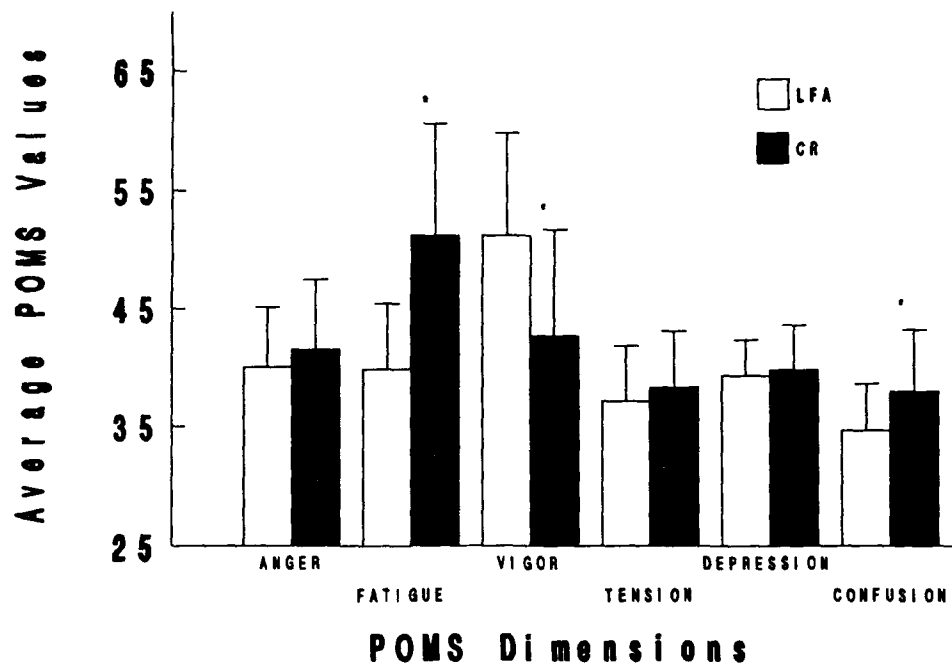
Figure 1. POMS values for pilots were different during LFA and CR for fatigue, vigor and confusion.

Table 3. POMS dimensions affected by flight hours or sleep hours within 24 or 48 hour periods during each of the cumulative flight hour blocks for LFA and CR intervals ($p < .05$).

	CUMULATIVE FLIGHT HOURS			
	$\leq$75 H	75-100 H	100-125 H	$\geq$125 H
LFA				
FLIGHT 24 HRS	-	-	-	-
FLIGHT 48 HRS	DEPRESSION	-	TENSION	-
SLEEP 24 HRS	-	-	-	-
SLEEP 48 HRS	-	-	-	VIGOR
CR				
FLIGHT 24 HRS	-	-	-	VIGOR
FLIGHT 48 HRS	-	-	-	-
SLEEP 24 HRS	-	-	-	-
SLEEP 48 HRS	-	-	-	VIGOR

Table 4. The mean temperature, time entered, number of flight hours and sleep in 48 and 24 hours, the cumulative flight hours and the POMS fatigue scores associated with the overall (Mean Total), and the maximum mean POMS fatigue scores for LFA and CR.

	N	MEAN (TOTAL)	MEAN (LFA)	MEAN (CR)
Temperature (F°)	81	97.7	97.5	97.6
Time (24 Hrs)	379	1136	1015	1050
Flight 48 Hrs	327	12.5	11.2	14.7
Flight 24 Hrs	300	8.1	5.2	8.4
Sleep 48 Hrs	354	14.0	12.3	11.7
Sleep 24 Hrs	336	7.8	6.4	6.8
Cumulative Hrs	377	94.1	62.9	88.9
Poms Fatigue	379	45.3	57.0	61.3

The differences between LFA and CR intervals, in particular those for fatigue and vigor, indicated that crew rest was restorative. Cumulative flight hour blocks alone did not account for significant effects on mood. However, combining cumulative flight hours per 30-day period with decreasing hours of recent sleep affected the POMS vigor dimension during LFA and CR intervals only when cumulative flight hours exceeded 125 hours. Vigor seems therefore to be the most sensitive of the POMS dimensions to cumulative flight hours in excess of 125 hours per 30-days when the amount of sleep in the past 24 hours are considered. Vigor was also affected when flight hours in the past 24 hours are considered. It is interesting as well, that the extreme POMS fatigue scores were associated with the early morning hours for LFA and CR, times that were associated with approximately 0400 Charleston AFB time. Since this would correspond to the trough in the sleep-wake cycle of diurnally active crews, this finding might indicate a circadian mood sensitivity.

The minimum crew rest interval is 12 hours. This interval starts when the aircraft lands. Therefore, it may be inappropriate to be called a crew rest interval since it includes time to get transportation to the operations building, return weapons, receive intelligence briefings, get transportation to the billeting, get a meal and so on. This process could often take 3-6 hours off the crew rest interval and jeopardize the amount of sleep obtained. An effective rest period should be actual rest time. Other papers in this symposium address the importance of the crew rest environment associated with the crew rest interval (1). It is the conclusion of this paper that attending to recent sleep and flight histories as well as cumulative flight history may improve vigor and mood when operational pressures require exceeding 125 flight hours per 30-day.

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C-141 AIRCREW SLEEP AND FATIGUE DURING THE PERSIAN GULF CONFLICT

Patricia A. Boll
William F. Storm
Jonathan French
Roger U. Bisson
Stephen D. Armstrong
Timothy Slater
William E. Ercoline[1]
Robert L. McDaniel[2]

Sustained Operations Branch
Armstrong Laboratory
Brooks Air Force Base, Texas, USA, 78235

Krug Life Sciences[1]
San Antonio, Texas, USA, 78216

437 Military Airlift Wing[2]
Charleston Air Force Base, South Carolina, USA, 29404

SUMMARY

Subjective fatigue ratings and sleep logs were col-
lected from pilots flying C-141 strategic airlift mis-
sions during Operations Desert Shield and Desert
Storm. Descriptive summaries of the data are pre-
sented for duty-day, crew rest away from home
base, and crew rest at home base. The implications
of selected findings are presented as recommen-
dations on management of aircrew work/rest sched-
ules during sustained airlift operations.

1. INTRODUCTION

The United States Air Force (USAF) Military Air-
lift Command (MAC) initiated airlift missions to
the mid-east in support of the Persian Gulf conflict
on 4 August 1990. Operation Desert Shield was to
become the most massive and rapid movement of
personnel and materiel in military history. At the
peak of the initial buildup, MAC was completing
300 strategic missions per day. By early December
1990, MAC had conducted 6,400 missions and air-
lifted more than 200,000 personnel and 210,000 tons
of equipment. Intense airlift operations to the
Persian Gulf continued uninterrupted during Opera-
tion Desert Storm and for several months thereaf-
ter. A few days after the initiation of Desert
Shield, the MAC Command Surgeon requested that
we document and evaluate aircrew fatigue in C-141
pilots participating in the operation. In February
1991 MAC requested we expand and continue our
evaluation during the latter days of Desert Storm.

2. METHOD

Data collection and analyses were based on the
activities and phases that make up an airlift mission.
When gone from home base on flying duties for
more than one day, MAC airlift crews refer to the
entire interval from departure to return to their
home base as a trip. A trip may last a few or sev-
eral days and is comprised of alternating duty days
and crew rest periods. Duty days may be up to 16
hours in duration for a standard o.- "basic" two-pilot
crew, and 24 hours when an extra pilot is added to
or "augments" the crew (4). Duty days include pre-
flight, flight, and post-flight activities. A duty day
may be composed of one to four legs, with each
take-off to landing sequence being a leg. A duty
day begins one hour after being alerted for flying
duty and ends when the aircraft blocks-in and the
crew is directed to enter crew rest. Crew members
accumulate flying hours from each take-off to land-
ing. Cumulative flying hours are carefully docu-
mented and are limited by regulation to 125 hours
per 30 consecutive days.

The minimal crew rest interval is 12 hours (4), including time for meals, transportation, and eight hours of sleep. On completion of crew rest, a crew becomes legal for alert, meaning they are available for assignment to flying duty. A duty day does not begin until assigned or "alerted" for a mission. On entering crew rest aircrews are usually issued an expected alert time. If they have not been alerted within 6 hours of the expected alert time they are returned to crew rest for at least another 12 hours. Crew rest at a base away from home is defined as being in "stage" and the base is a "staging base."

It is common practice to use the terms "trip" and "mission" interchangeably. However, a mission is a designated airlift requirement to transport cargo between bases. A crew will typically fly a succession of missions, or legs of missions, during a trip. When a crew enters crew rest the mission will continue on with a new, rested crew. In some cases a mission will align temporally with a duty day, and occasionally a crew may be assigned to a special mission over several duty days.

During Desert Shield and Desert Storm, some exceptions were made to MAC regulations and policies addressing aircrew management. Crews were frequently held in legal for alert status for more than 6 hours. A waiver was enacted permitting 150 flying hours per 30 days. We were specifically requested to evaluate, if possible, the effects of the increase in flying hours on crew fatigue. The basis for the 125-hour limit and the advisability of increasing it temporarily or permanently to 150 hours is not clear. The crew members we evaluated in Desert Shield and Desert Storm were granted scheduling priority whenever possible to allow them to rapidly accumulate the maximum flying hours possible during the fatigue evaluations.

The evaluation of aircrew fatigue during Desert Shield occurred over a 45-day period from 18 August to 10 October 1990. Fourteen C-141 pilots assigned to the 437 Military Airlift Wing, Charleston Air Force Base (AFB), South Carolina, participated in the study. The pilots were paired into seven crews with the intent that each pair would be assigned as pilot and co-pilot to the same trips throughout the evaluation. This objective was maintained with limited success. Most of the missions flown by the 14 pilots were augmented with a third pilot, as was the policy for all Desert Shield missions through late September 1990. Augmentee

pilots did not participate in the fatigue evaluation.

In operational evaluations, experience has shown that first-hand participation by the research team promotes credibility and compliance with data collection procedures. For this effort, however, MAC initially determined that, as noncombatants, Armstrong Laboratory investigators should not accompany aircrews on Desert Shield missions due to the danger of potential warfare. We therefore positioned ourselves at key staging bases to collect completed data from the crewmen as they transited through the airlift system. These bases were Charleston AFB, SC, Torrejon Air Base (AB) and Zaragoza AB, Spain, and Rhein Main AB, Germany. Evaluation procedures were employed that could be self-administered by the participating crewmen and required little training and only a few minutes for completion. (As Desert Shield settled into a smooth operation, the Armstrong Laboratory personnel were permitted to fly some missions to the Persian Gulf from their assigned staging bases. Participation in these missions provided first-hand exposure to the operational stresses imposed by the very long duty days flown during Desert Shield.)

Eleven C-141 pilots from the 437 Military Airlift Wing participated in the fatigue evaluation conducted during Desert Storm. Data were collected for 38 days from 18 March to 24 April 1991. Pairing the 10 original participating pilots and co-pilots into crews was mostly successful. Two of the pilots did not participate throughout the evaluation, one of which was replaced by the eleventh participant. Members of our evaluation team were permitted to fly on Desert Storm missions. Each member of the team was assigned to an aircrew. The evaluator participated in all phases of his/her assigned crew's schedule during the study, including flying on all missions. None of the Desert Storm missions were augmented with a third pilot. The evaluation procedures used in Desert Shield were also employed in Desert Storm, sometimes with slight modifications in schedule. Two additional measurements were included in Desert Storm; mood or affect was surveyed, and an attempt was made to evaluate pilot flying performance.

Daily Log. Throughout the evaluations, each pilot was responsible for maintaining a daily log (Fig. 1). Daily activities, oral temperatures, and subjective fatigue ratings were hand-recorded on the log by the participating pilot. Typically the daily log was updated 4-5 times a day at the pilots' convenience.

ACTIVITY LOG

Date (Z)	mid	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Activity Log																								
Subj. Fatigue																								
Time of Temp.																								
Temperature																								
Location																								

ACTIVITY LOG

Write the proper code for your predominate activity in each of the 48 half-hour blocks.

S = Sleeping (at any location)

A = Awake in Bed, Trying to Sleep

F = Flying

Y = AF Duties

P = Personal Activities

M = Well Balanced Meal

K = Snack Foods

O = Other (Please Indicate)

SUBJECTIVE FATIGUE

Write the number of the statement which describes how you feel RIGHT NOW.

1 = Fully Alert; Wide Awake; Extremely Peppy

2 = Very Lively; Responsive, but not at Peak

3 = Okay; Somewhat Fresh

4 = A Little Tired; Less then Fresh

5 = Moderately Fresh; Let Down

6 = Extremely Tired; Very Difficult to Concentrate

7 = Completely Exhausted; Unable to Function Effectively; Ready to Drop

LOCATION

Enter the FAA or ICAO code to indicate your ground location. Use an 'A' to indicate Airborne.

FIGURE 1

Activity. The times of occurrence, duration, and location of activities such as sleeping, eating, exercising, enroute flying, and mission planning were documented on the daily logs. Coordinated Universal Time (Zulu time) was used in all cases to document time of day.

Oral Temperature. Each participant was provided with a new digital oral thermometer. He was responsible for taking his oral temperature every four hours on the fourth hour when awake (participating crew members were never awakened for the purposes of data collection). The temperature was recorded by the crew member on the daily log for that date and time. These data were collected as part of an ongoing process to develop an objective measure of circadian rhythm disruption, a factor known to contribute to fatigue. During the Desert Storm evaluation the pilots were also requested to take their temperature just before retiring and just after awakening.

Subjective Fatigue Ratings. Simultaneously with taking oral temperature, the pilot rated his subjective feeling of fatigue using the descriptive, 7-point scale presented on the daily log. Fatigue ratings of 1, 2, and 3 reflect a rested, alert individual. Ratings of 5, 6, and 7 indicate a need for rest and sleep. Self-ratings of subjective fatigue can be associated with performance impairment (6).

Activity Monitors. Each pilot wore an activity monitor on his wrist like a watch. The activity monitor is a small, lightweight (3 oz.), sealed device containing miniature piezoelectric elements. Subtle arm and wrist movements are sensed by the device's electronics and stored as a function of time in resident memory. The movement data collected by the monitor provide a quantified estimate of the quality and quantity of sleep. The monitor required no attention from the wearer, other than removing it while bathing. Some of the activity monitors were provided by the Walter Reed Army Institute of Research.

Mood. The Profile of Mood States (POMS) survey is a paper-and-pencil instrument used to assess changes in affective and emotional state (5). The POMS response form presents a 5-point rating scale for each of 65 adjectives. Standardized scores are derived for each of six identifiable mood or affective states: tension; depression; anger; vigor; fatigue; and confusion. Desert Storm crew members completed POMS surveys upon entering crew rest and when legal for alert. A third form was completed when alerted if legal for alert status exceeded 4 hours.

Performance. During Desert Storm data recorded by the C-141 onboard digital flight data recorder (DFDR) were retrieved in an attempt to evaluate pilot flying performance. At the termination of each leg, the research evaluator downloaded the DFDR data onto a portable copy recorder using standard recording tape. On return to Charleston AFB the DFDR tapes were transferred to the Air Logistics Center, Warner-Robins AFB, Georgia, for further processing. Final data reduction and analyses of selected flight segments were conducted at Brooks AFB. Derived performance measures were evaluated for relationships to cumulative flying hours, legs flown per duty day, reported fatigue status, and sleep/wake cycles.

3. RESULTS AND RECOMMENDATIONS

Results and discussion of the subjective fatigue ratings and sleep histories are presented in this paper. Findings and their implications for mood, temperature, nutrition, and performance are presented in companion reports (1, 2, 3) at this symposium.

The 14 pilots that participated in the 45 days of evaluation during Desert Shield generated over 600 "pilot days" for analyses. During this period they completed 55 trips. Individual pilots each flew 3-5 trips. The 11 pilots studied during Desert Storm completed 380 "pilot days" and 29 trips during the 38-day evaluation period. Individual pilots completed 1-3 trips. When two of the pilots participating in the fatigue evaluations were on the same crew, two trips were counted for the purposes of data summaries.

Missing data occurred due to the demands of the missions and simply forgetting. In some instances considerable liberties were taken in summarizing fragmented data in order to maximize the information gained from the data available. Some pilots are represented more frequently than others. The data from some trips were excluded from some of the analyses based on the completeness of the data being assessed.

Subjective Fatigue During the Duty Day. Table 1 presents an overall summary of the distribution of 750 subjective fatigue ratings reported by the 14 Desert Shield pilots during 233 duty days that occurred over 55 trips. Table 2 presents analogous data for 678 fatigue ratings for the 11 Desert Storm pilots over 183 duty days and 29 trips. The data in Tables 1 and 2 are presented as percentages to allow comparison across duty days of various lengths. The fatigue ratings of 1-7 represent the seven rating choices presented on the activity log. The ratings occurring most frequently for each of the duty day durations are highlighted. Most pilots began each duty day refreshed and alert, with over 80% of the ratings for both sets of pilots being 1, 2, or 3. Not surprisingly, feelings of fatigue became more severe as the length of the duty day increased. It is notable that marked levels of fatigue (ratings of 5 and 6) were reported more than a quarter of the time for the Desert Shield pilots and almost a third of the time for the Desert Storm pilots when the duty day extended to >15 hours duration. When the duty day extended to >20 hours the Desert Shield pilots reported ratings of 5 or 6 in 50% of the cases and the Desert Storm pilots 84% of the cases.

Recommendation. Current MAC duty day limitations of 16 hours for basic crews and 24 hours for augmented crews are appropriate for maintaining crew performance and flight safety.

Sleep During the Duty day. Trips with incomplete sleep data were excluded from the analysis of sleep during the duty day, leaving for evaluation 198 duty days distributed over 47 trips during Desert Shield and 183 duty days occurring over 29 trips during Desert Storm. Essentially all (98%) duty day sleep occurred after the duty day exceeded 10 hours duration. Sleep occurred during 52% (102/198) of the Desert Shield duty days and 45% (82/183) of the Desert Storm duty days. Among the duty days on which sleep occurred, the average duration of the sleep acquired was 2.9 hours during Desert Shield and 1.6 hours during Desert Storm. Duty day sleep was usually acquired in one sleep period (80% for Desert Shield; 98% for Desert Storm). Most sleep during the duty day occurred while airborne, although a very few instances of sleep did occur during turn-arounds between legs on the ground.

Subjective Fatigue During Crew Rest Out in The System. Crew rest out in the system refers to being in official crew rest status at any staging base while away from home. Fatigue ratings reported just before and after the primary sleep period during each crew rest interval were analyzed. For each pilot a primary sleep period was identified for each crew rest interval using these criteria: (1) select the first sleep period of 5 or more hours duration -- in most cases this was the first sleep period during the crew rest period; and (2) if none of the sleep periods were as long as 5 hours, the longest was used. Both a pre- and a post-sleep fatigue rating had to accompany a sleep period for the fatigue ratings to be included in the analysis.

Against these criteria, 133 primary sleep periods from the 47 Desert Shield trips and 107 primary sleep periods from the 29 Desert Storm trips had pairs of pre- and post-sleep ratings available for analysis. Frequency distributions for the percentage of fatigue ratings reported before and after the primary sleep periods in crew rest are presented in Tables 3 and 4. Forty-nine percent of the Desert Shield pre-sleep fatigue ratings and 60% of the Desert Storm pre-sleep fatigue ratings were 5, 6, or 7 (average ratings of 4.4 and 4.8, respectively). Eighty-six percent and 73% of the post-sleep ratings were 1, 2, or 3 (average ratings of 2.5 and 2.9, respectively). There were no apparent trends related to successive trips or successive crew rest periods.

Sleep During Crew Rest Out In the System. During the fatigue evaluations, total crew rest time (crew rest + time in legal for alert status) at the staging bases was usually of 20-22 hours for the Desert Shield pilots and 16-18 hours for the Desert Storm pilots. Sleep was usually fragmented over 2-3 periods during each crew rest for the Desert Shield pilots but often occurred over one uninterrupted period for the Desert Storm pilots. Two separate analyses were performed to evaluate sleep during crew rest periods while out in the system. The first analysis found the Desert Shield pilots averaged 7.2 hours of sleep and the Desert Storm pilots 7.6 hours of sleep for the primary sleep periods occurring during the crew rest intervals (133 intervals for Desert Shield; 107 intervals for Desert Storm) for which fatigue ratings were discussed above. The second analysis determined the total amount of sleep acquired during the crew rest interval. The Desert Shield pilots averaged 9.1 hours of total sleep time during the 151 crew rest periods occurring during 198 duty days. The Desert Storm pilots averaged 8.9 hours of total sleep time during 154 crew rest periods over 183 duty days.

TABLE 1

FREQUENCY DISTRIBUTIONS (%) OF FATIGUE

RATINGS BY DUTY DAY HOURS

(DESERT SHIELD)

Cumulative Duty Day Hours	FATIGUE RATING						
	1 ALERT	2	3	4	5	6	7 EXHAUSTED
0 - 5:	9	45	30	14	1	1	0
>5 - 10:	3	25	37	21	12	2	0
>10 - 15:	2	12	31	29	21	4	0
>15 - 20:	1	10	27	33	26	2	0
>20 - 25:	0	10	18	21	43	7	0

TABLE 2

FREQUENCY DISTRIBUTIONS (%) OF FATIGUE

RATINGS BY DUTY DAY HOURS

(DESERT STORM)

Cumulative Duty Day Hours	FATIGUE RATING						
	1 ALERT	2	3	4	5	6	7 EXHAUSTED
0 - 5:	12	41	29	14	4	<1	0
>5 - 10:	5	30	33	22	8	2	0
>10 - 15:	0	18	35	30	11	7	0
>15 - 20:	0	3	23	43	31	0	0
>20 - 25:	0	0	0	17	67	17	0

TABLE 3

FREQUENCY DISTRIBUTIONS (%) OF FATIGUE RATINGS

BEFORE AND AFTER CREW REST OUT IN THE SYSTEM

(DESERT SHIELD)

| | FATIGUE RATING | | | | | | |
	1 ALERT	2	3	4	5	6	7 EXHAUSTED
Pre-Sleep:	0	4	19	29	31	17	1
Post-Sleep:	14	39	33	12	1	0	0

TABLE 4

FREQUENCY DISTRIBUTIONS (%) OF FATIGUE RATINGS

BEFORE AND AFTER CREW REST OUT IN THE SYSTEM

(DESERT STORM)

| | FATIGUE RATING | | | | | | |
	1 ALERT	2	3	4	5	6	7 EXHAUSTED
Pre-Sleep:	0	0	12	30	37	16	7
Post-Sleep:	3	40	30	18	8	2	0

By calculating the number of nights away from home base, it was possible to convert the time slept while out in the system (crew rest + duty day) to the average time that would have been slept per night if the pilot had slept the same amount of time at home. The Desert Shield pilots would have averaged 6.4 hours and the Desert Storm pilots 6.7 hours of sleep per night. Assuming a typical sleep period of 7.5 hours per night at home, the pilots averaged 0.8 - 1.0 hour of sleep loss per day while out in the system.

First hand observation and comments from the pilots and other crew members indicate that application of common sense management would have often improved the quantity and quality of sleep and recovery attainable at staging bases. An example cited was the use of a power chain saw to trim trees next to an aircrew rest facility. Broad-based noise abatement should be instigated during a surge such as Desert Shield/Desert Storm. Limit two crew members to a room and have members of the same crew share connecting bathrooms. Bioenvironmental control of temperature and light are critical for sound sleep during local night and daytime. Good food is important for both health and morale. A variety of nutritious food and drink should be available 24 hours a day. Inflight meals (especially those prepared at European staging bases) were too often high in fat and sugar and offered inadequate nutrition for the endurance demands of a sustained surge (3).

Recommendation. Potential staging bases should prepare and practice contingency plans that provide around-the-clock sleep management and convenient access to nutritious food for transient aircrew and support personnel involved in deployments and sustained operations.

On the positive side, it was noted that unit commanders, aircraft commanders, and aircrew in general are much better educated on the insidiousness of cumulative fatigue and the importance of managing fatigue than was the case 10 years ago. There was little or no stigma attached to admitting to being "too tired" or requesting additional crew rest time.

Even though they were given scheduling priority, the pilots participating in our Desert Shield evaluation often experienced being in legal for alert status for 8-10 hours at the staging bases. Crews not receiving priority waited in legal for alert status for 12-14 hours. These undefined waiting periods prohibited the pilots from being able to schedule their time to most effectively manage both personal and operational requirements, since they could not determine when a mission assignment would occur. Scheduling of all the aircrews at the staging bases became more efficient as the airlift progressed. As a result, the Desert Storm pilots participating in the fatigue evaluation averaged only 4 hours in legal for alert status. (The relatively short period of time spent in legal for alert status by the Desert Storm pilots was probably partially responsible for them reporting less fragmented sleep patterns.) The Desert Shield and Desert Storm pilots enjoyed their preferential treatment at the staging bases and felt strongly that it reduced fatigue and improved morale.

Recommendation. Cumulative fatigue can be reduced by limiting legal for alert status to 6 hours during contingency operations involving 20+ hour duty days and 12-hour crew rest. This recommendation to MAC resulted from the Desert Shield study and was implemented to the extent possible during Desert Storm.

Subjective Fatigue During Recovery at Home Base. Evaluation of crew recovery upon returning home to Charleston AFB was based on the first primary sleep period (5 or more hours in duration) reported by each pilot during his first three, 24-hour periods home. It can be noted that upon return to Charleston, the pilots tended to immediately adhere to local social schedules. Therefore, most of the primary sleep periods at home occurred about once per 24 hours. In several cases during Desert Shield only one or two primary sleep periods were available for study, due to a pilot departing on another trip. During Desert Storm pilots were more apt to receive two or three, and in some cases even four, days of recovery before departing on another trip.

Fatigue ratings reported just before and after the primary sleep periods during the first three 24-hour periods of home-base recovery were evaluated. Only fatigue ratings for sleep periods having both a pre- and a post-sleep rating were included (50 for Desert Shield; 54 for Desert Storm). The distribution (percentages) of pre- and post-sleep fatigue ratings for the primary sleep periods occurring during the first three 24-hour periods home are presented in Tables 5 and 6. Sixty-six percent of

TABLE 5

FREQUENCY DISTRIBUTIONS (%) OF FATIGUE RATINGS

BEFORE AND AFTER RECOVERY SLEEP AT HOME

(DESERT SHIELD)

	FATIGUE RATING							
	1 ALERT	2	3	4	5	6	7 EXHAUSTED	
1st 24 Hrs.								
Pre-Sleep:	0	0	11	22	22	33	11	(18)*
Post-Sleep:	28	22	33	17	0	0	0	
2nd 24 Hrs.								
Pre-Sleep:	0	11	16	42	32	0	0	(19)
Post-Sleep:	26	47	26	0	0	0	0	
3rd 24 Hrs.								
Pre-Sleep:	0	15	23	15	46	0	0	(13)
Post-Sleep:	15	54	30	0	0	0	0	

*Value in parentheses is the sample size for each 24-Hr recovery period.

TABLE 6

FREQUENCY DISTRIBUTIONS (%) OF FATIGUE RATINGS

BEFORE AND AFTER RECOVERY SLEEP AT HOME

(DESERT STORM)

	FATIGUE RATING							
	1 ALERT	2	3	4	5	6	7 EXHAUSTED	
1st 24 Hrs.								
Pre-Sleep:	0	5	14	38	24	19	0	(21)*
Post-Sleep:	4	29	43	19	0	5	0	
2nd 24 Hrs.								
Pre-Sleep:	0	5	27	32	18	14	5	(22)
Post-Sleep:	5	36	45	9	5	0	0	
3rd 24 Hrs.								
Pre-Sleep:	0	9	18	56	9	9	0	(11)
Post-Sleep:	9	36	36	9	9	0	0	

*Value in parentheses is the sample size for each 24-hr recovery period.

the Desert Shield pilots' responses prior to the first recovery sleep period were ratings indicating moderate to considerable fatigue (ratings of 5, 6, or 7). Forty-three percent of the Desert Storm pilots' responses were ratings or 5, 6, or 7, with another 38% reporting ratings of 4. Upon arising from the first recovery sleep period, ratings of 1, 2, or 3 were reported 83% of the time by the Desert Shield pilots and 76% of the time by the Desert Storm pilots. In general, fatigue ratings reported prior to retiring for the second and third sleep periods at home were not as severe as prior to the first sleep period and post-sleep ratings indicated recovery for all of the Desert Shield pilots and most of the Desert Storm pilots.

Sleep During Recovery at Home Base. The total amount of sleep acquired by each pilot during each of the first three 24-hour periods home was calculated for the 90 recovery days on which sleep data were reported by the Desert Shield pilots and the 66 recovery days for which the Desert Storm pilots reported sleep data. Respectively for the Desert Shield and Desert Storm pilots, an average of 9.3 and 9.2 hours were slept during the first 24-hours home, 8.1 and 8.7 hours for the second 24 hours, and 8.4 and 8.4 hours for the third.

Recommendation. Based on the Desert Shield fatigue and sleep findings, we suggested that aircrew receive 36-60 hours of crew rest every 6-8 days, providing an opportunity for at least two normal sleep periods. When feasible, this extended rest should occur at home base.

Returning Home With More Than 140 Hours Cumulative Flying Time. In an attempt to address the issue of increasing the allowable cumulative flying hours from 125 to a 150 hours per 30 days, Desert Shield aircrew fatigue and sleep data were evaluated for instances when pilots returned to Charleston AFB with exceptional amounts of cumulative flying hours. A comparison was made between six of the Desert Shield pilots returning home with more than 140 hours versus their and other pilots' return home with less than 140 hours. Bearing in mind that this comparison takes considerable statistical liberties in dichotomizing the data, a comparison of average fatigue ratings reported before and after the first three primary sleep periods is presented in Table 7. While the average feelings of fatigue just prior to the initial sleep period were at notable levels for both returning home with less than and more than

140 hours (4.9 and 5.8, respectively), the average rating was greater for the more than 140 hours condition. The average pre-sleep fatigue rating continued to be relatively higher for the greater than 140-hour group during the second 24-hour recovery period.

A comparison analogous to that for the fatigue data is presented in Table 8 for the average hours slept per 24-hour period by the Desert Shield pilots upon returning home with less than and more than 140 hours. These data indicate that, compared to a typical 7.5 to 8 hours of sleep a night, an extra 1.0-1.5 hours of sleep were still desired after three days recovery when returning home with more than 140 hours.

Seven of the Desert Storm pilots returned from their third trip with more than 140 cumulative flight hours for the past 30 days. These fatigue and sleep data were compared to all the other data reported by the Desert Storm pilots when returning home with less than 140 cumulative flight hours. The summary data presented in Table 9 are not consistent with the Desert Shield data. In this instance the pilots returning home with more than 140 cumulative flight hours reported an average rating prior to retiring that indicated only modest fatigue and less fatigue than that reported by the pilots returning with under 140 cumulative hours. As was the case with the Desert Shield data, the recuperative value of three nights of sleep is apparent for both groups. However, the Desert Storm pilots returning with more than 140 cumulative flight hours did not sleep more than is typical and slept less than that reported when returning home with less than 140 cumulative hours (Table 10).

Recommendation. Based on the Desert Shield findings, we recommended that MAC maintain the limit of 125 hours/30 days, waivering to 150 hours if necessary. Although the Desert Storm data did not support the earlier results, we feel strongly that this is prudent guidance until definitive research can be conducted.

It became apparent from monitoring and talking with the pilots that the number of cumulative flying hours per 30 days does not, by itself, always provide an accurate picture of the crewman's "fatigue" status and fitness for duty. This metric is not sensitive to the recent history of the crew member. It would be useful to develop additional guidelines that attend

TABLE 7

AVERAGE FATIGUE RATINGS BEFORE AND

AFTER SLEEP DURING RECOVERY AT HOME BASE

(DESERT SHIELD)

	Return with <140 hrs		Return with >140 hrs	
	Pre-Sleep	Post-Sleep	Pre-Sleep	Post-Sleep
First 24 Hours:	4.9	2.4 (14)*	5.8	2.5 (4)
Second 24 Hours:	3.6	2.3 (14)	4.8	1.6 (5)
Third 24 Hours:	4.2	2.3 (8)	3.6	2.0 (5)

*Value in parentheses is the sample size for each pair of pre- and post-sleep fatigue ratings.

TABLE 8

AVERAGE HOURS SLEPT DURING RECOVERY AT HOME BASE

(DESERT SHIELD)

	Return with <140 hrs		Return with >140 hrs	
First 24 Hours:	9.2 hr	(35)*	9.8 hr	(6)
Second 24 Hours:	8.0 hr	(23)	8.8 hr	(6)
Third 24 Hours:	8.2 hr	(15)	9.0 hr	(5)

*Value in parentheses is the sample size on which the average hours slept is based.

TABLE 9

AVERAGE FATIGUE RATINGS BEFORE AND

AFTER RECOVERY SLEEP AT HOME BASE

(DESERT STORM)

	Return with <140 hrs		Return with >140 hrs	
	Pre-Sleep	Post-Sleep	Pre-Sleep	Post-Sleep
First 24 Hours:	4.6	2.9 (15)*	3.8	3.0 (5)
Second 24 Hours:	4.0	2.5 (15)	4.8	3.3 (6)
Third 24 Hours:	3.7	2.5 (6)	4.2	3.0 (5)

*Value in parentheses is the sample size for each pair of pre- and post-sleep fatigue ratings.

TABLE 10

AVERAGE HOURS SLEPT DURING RECOVERY AT HOME BASE

(DESERT STORM)

	Return with <140 hrs		Return with >140 hrs	
First 24 Hours:	9.7 hr	(19)*	7.5 hr	(7)
Second 24 Hours:	8.9 hr	(16)	7.9 hr	(7)
Third 24 Hours:	8.5 hr	(8)	8.3 hr	(7)

*Value in parentheses is the sample size on which the average hours slept is based.

to the crew member's activities and workload over
the last 72-96 hours. Crew scheduling and safety
may be enhanced by considering both the immedi-
ate and the cumulative duty history. Companion
papers presented at this symposium by Bisson et al.
(1) and French et al. (2) address this issue.

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THE EFFECTS OF COCKPIT HEAT ON AVIATOR SLEEP PARAMETERS

J. Lynn Caldwell
Robert Thornton
Jacquelyn Y. Pearson
Barbara L. Bradley
U.S. Army Aeromedical Research Laboratory
P.O. Box 577
Fort Rucker, AL   USA   36362-5292

1   SUMMARY

Aviators are frequently required to work in hot environments while performing the complex cognitive tasks necessary to fly their aircraft. In the present study, objective measures of sleep were taken to determine the effects of exposure to high cockpit temperatures. Army helicopter pilots were required to fly a UH-60 simulator while wearing NBC IPE in temperatures of 35°C and 41°C. Additionally, various cooling vests were tested to determine if these cooling mechanisms would alleviate any heating effect seen in sleep parameters. During the day, pilots flew the simulator continuously for 6 h unless they were withdrawn because of excessive core temperature or they voluntarily withdrew. During the night, pilots slept in a cool bedroom in the laboratory while their sleep patterns were recorded by electroencephalography. Analyses of the data indicated when core body temperature rose during the flight by at least 1°C and the flight was at least 5 h in length, rapid eye movement (REM) sleep was significantly reduced. No rise in slow wave sleep (SWS) was seen although there was a tendency for the relationship between SWS and REM sleep to be altered. The results suggest aviators operating in a hot environment for a long period of time may have altered sleep the following night.

2   INTRODUCTION

The effects of body heating through exercise on sleep parameters have been evaluated extensively (see review by Horne, 1). In addition to body heating through exercise, the effects of passive body heating on sleep have also been evaluated (2-4). Even when people are inactive while body temperature is elevated, the effects of this heating are seen during the subsequent night's sleep.

Most of the research investigating passive body heating on sleep parameters have found that slow wave sleep (SWS) increases and rapid eye movement (REM) sleep decreases, particularly in the first half of the night. In a study by Horne and Reid (2), six young females were immersed in warm water, either 41°C or 35.5°C, for three periods of 30 minutes each, with a 10-minute rest separating the periods. Core body temperature rose an average of 1.8°C (sd = 0.3°C) in the hot condition. The other condition did not produce a rise in core temperature and was considered a thermoneutral condition. Examination of the subsequent night's sleep (8 hours after heat exposure) indicated that SWS increased during the entire night, and REM sleep decreased in the first half of the night.

Bunnell and associates (3) investigated the effects of passive body heating at different times from the sleep period. Eight subjects were immersed in warm water (41°C) for two blocks of 30 minutes each, separated by a 30-minute rest period. The subjects were immersed in water at four different times on separate days--early morning, afternoon, early evening, and late evening. The results indicated that the first SWS cycle increased after the late evening heat period. Additionally, REM sleep was reduced during the first REM period. Sleep was not affected after the morning or afternoon heat periods and only affected slightly after the early evening period.

With these effects on sleep architecture after relatively short periods of body heating, it seems likely that continuous body heating for as long as 6 hours would contribute substantially to sleep architecture changes. Army helicopter pilots who are required to fly their aircraft in hot environments are subjected to high temperatures in the cockpit for several hours at a time. In addition to high environmental temperatures, pilots may also be required to fly in these hot environments while wearing chemical protective clothing when there is a significant threat of the use of chemical agents by an enemy. If such a situation arose, it would be beneficial to know the physiological consequences. The assessment of changes in sleep would be helpful in order to determine the extent of physiological effects which occur during high heat conditions. If heat stress increases the need for slow wave sleep, it is possible that a pilot returning from a mission during which heat stress was experienced may have an increase in fatigue which, in turn, may lead to a decrease in performance. Commanders may need to consider the time required by the pilot to recuperate from such a mission.

The present study was part of a larger study to determine the effects of wearing chemical protective clothing in a hot cockpit on flight performance. In addition, two microclimate cooling devices were tested to determine if the effects of heat on the pilot could be minimized. Only the effects of heat on sleep parameters will be discussed in this paper. A full report of the effects of heat on performance is available (5).

3   METHODS

3.1 Subjects

Subjects for the study were 16 volunteer male Army aviators, between the ages of 21 and 39. Only 8 of the subjects agreed to take part in the sleep component of the study. This subset of subjects ranged in age from 25 to 37, with a mean age of 33.5 (sd

– 3.7). All were good sleepers, however, two of the subjects did not have standard sleep times due to a shiftwork schedule at their regular jobs.

3.2 Apparatus

3.2.1 Sleep recordings

A Nihon Kohden polygraph was used to collect electroencephalographic (EEG), electrooculographic (EOG), and electromyographic (EMG) data from the participants. EEGs were recorded from C_3, C_4, O_1, and O_2 referenced to the contralateral mastoids using Grass E5SH silver cup electrodes. The time constant was set at 0.3 and the high filter was set at 35 Hz. ECG was recorded from the outer canthus of each eye. The time constant was set at 5.0 and the high filter was set at 15 Hz. EMG was recorded with submental electrodes, with a time constant of 0.003 and a high filter setting of 120 Hz. The 60 Hz notch filter was not used except when absolutely necessary. Collected data were recorded on standard paper traces for later hand scoring.

3.2.2 Simulator

The U.S. Army Aeromedical Research Laboratory (USAARL) UH-60 helicopter simulator was used to imitate a helicopter flight mission. In addition to the standard training simulator characteristics, the USAARL simulator has an environmental control system (ECS) to regulate the cockpit thermal environment by specifying dry bulb temperature (15.5°C - 41.5°C) and relative humidity (50 - 90%). It is linked to a real time data acquisition system on a DEC VAX 11/780 computer which can record and analyze aircraft flight parameters and pilot inputs.

The environmental conditions used in the study were 35°C with 50% relative humidity, and 41°C with 50% relative humidity. The solar radiation load was simulated by using infrared lamps to produce a radiant heat load on the helmet of the subjects of 130 watts per square meter (measured 1900 mm from the simulator floor) and 100

watts per square meter over the legs (measured 560 mm from the floor).

3.2.3 Clothing

The subjects were required to wear chemical protective clothing during the test portion of the study. The Aircrew Uniform Integrated Battlefield (AUIB) is a two-piece garment combining both thermal and chemical protection for aviators. It is constructed of sage green 4.5 ounce plain weave Nomex-Kevlar/polytetrafluoroethylene (PTFE) laminated outer shell and charcoal impregnated polyurethane foam/tricot laminated liner. There is a sleeved port in both sides to allow passage of a microclimate cooling hose and tapes to seal around it. It is worn with the M43E-1 aircrew member's protective mask and the survival armor recovery vest.

The M43E-1 mask consists of a bromobutyl facepiece with an integrated butyl hood and skirt. Overpressure is provided within the mask by a blower assembly, a battery-powered motor which blows air to the hood through two standard NBC filters. Some of the air flow is directed over the inside of the lenses to prevent misting, and some over the scalp to provide cooling. It incorporates a microphone and drinking tube.

Two thermoelectric microclimate cooling systems, designated as the aviator microclimate conditioning system (AMCS), have been developed in parallel by Aviation Systems Command (AVSCOM), St. Louis, Missouri. One is based on air conditioning, the other on liquid. The air cooled version of the AMCS is used with the second generation version of a single piece cooling vest, designed by Natick Research Development and Engineering Center (NRDEC), Natick, Massachusetts. It is worn over a T-shirt, immediately underneath the AUIB. Contaminant-free air is introduced to the vest through the airhose which attaches to a female connector on the side of the vest and has a quick disconnect attachment on the other end to interface with the aircraft subunit hose connector. The

cooler supplies air at a flow rate of 5.66 liters per second (12 cfm) for each of four stations, providing a theoretical cooling capability of 250 watts. Subjects were allowed to control their own flow rate, by selecting the high, low, vent, or off setting. This was as the result of a positive decision at the start of the study to use realistic cooler conditions rather than regulating flow rate and temperature to constant values. In practical terms, there will always be some variation from the specified values, especially when several aircrew share the same cooling source. The vent setting allows the blower fan to be used without thermoelectric cooling, and this was used on one of the test days to simulate cooling failure.

The liquid cooling unit was used in conjunction with the Exotemp vest and hood. The Exotemp vest is a long-sleeved turtle neck shirt. The garments are made of Nomex fabric and are lined with thin plastic tubing (1/8 inch outside diameter) to carry the coolant. The vest was worn in place of a T-shirt. The hood was used to give the subjects the advantage of head cooling, in the knowledge that, in practice, it can be disconnected if not necessary or desired.

4   PROCEDURES

Each subject was tested over a period of nine days. The first day served as a training day/adaptation night, and the second day served as a training day/baseline night. During the two training days, the subjects flew the simulator wearing their standard flight suit; the cockpit temperature was 21°C ($\pm$ 2°C); the relative humidity was 45%. The test days consisted of seven conditions: 1) 35°C, no cooling, 2) 35°C, air cooling, 3) 35°C, liquid cooling, 4) 41°C, no cooling, 5) 41°C, air cooling, 6) 41°C, liquid cooling, and 7) 41°C air cooling with only the blower. Due to equipment problems with the cooling mechanism, data from the 41°C air cooling with only the blower were not included in the analysis. The order of the conditions were randomized with the

restriction that none of the days which resulted in the most heat stress (41°C, no cooling, 41°C no cooling, and 41°C air cooling with only the blower) were allowed to be consecutive, to minimize any possible cumulative effects of heat stress or dehydration.

On each of the test days, subjects were required to walk a treadmill (4.8 km per h, 0° slope) for 20 minutes before the flight in order to simulate the workload used during preflight inspections. They then walked to the simulator and flew the flight profile; the profile usually began between 0900 and 0930. The subjects flew the simulator for 6 hours or until they were withdrawn from the flight due to safety measures or they voluntarily withdrew. A subject was withdrawn from the simulator for safety reasons if his core body temperature (as recorded by a rectal thermometer) reached 39.5°C. The details of the flight portion of the study are written elsewhere (5).

After the flight profile was completed, the subjects were given free time until bedtime. On the first night of the study, each subject had four EEG electrodes attached to his scalp, one EOG electrode attached to the side of each eye, and two EMG electrodes attached under the chin. Each electrode site was cleaned with acetone in order to reduce impedance. Each EEG electrode was filled with electrode gel and attached to the scalp with collodion. The EOG and EMG electrodes were filled with electrode cream and secured to the skin with surgical tape.

The EEG were recorded from sites C_3, C_4, O_1, and O_2, according to the International 10-20 System. Contralateral mastoid sites served as reference. EOGs were recorded from electrodes placed on the outer canthus of each eye, referenced to the left mastoid site. Submental EMG were recorded from electrodes attached under the chin. A ground electrode was placed on the forehead at site Fp_z. Impedances from the EEG sites were no more than 5000 ohms.

Impedances from the EOG and EMG electrodes were no more than 10,000 ohms.

After the electrodes were attached, the subject slept in a private, darkened bedroom located in the laboratory. The bedroom was maintained at an average temperature of 21°C. The subjects were allowed as many blankets as needed in order to remain comfortable. An intercom was placed next to the bed in case the subject needed anything during the night. The subjects began electrode hookups at 2100 hours each evening, with lights out between 2200 and 2300 hours, depending upon the subject's normal bedtime. The subject slept through the night, with a technician at the polygraph at all times, and awakened at 0600 the next morning. The EOG, EMG, and mastoid electrodes were disconnected and the subject allowed to shower and dress before he began the testing sessions for the day.

5   DATA ANALYSIS

Each subject's polysomnogram for nights 2 through 9 was visually scored for stage using standardized criteria (6). Stages 1, 2, 3, 4, REM, and movement time were scored for each 30-second epoch from lights out until lights on the following morning. Each subject's data were scored by only one person, but three scorers were used to score the eight subjects. Reliability among scorers was randomly checked on two records from every subject. Percent agreement among scorers ranged from 83 to 93 percent, with an average of 87.5 percent.

The first night served as acclimation; the second night which followed a training day in the simulator served as baseline. The conditions analyzed were baseline, 35° no cooling, 35° air cooling, 35° liquid cooling, 41° no cooling, 41° air cooling, and 41° liquid cooling. The variables analyzed from the sleep data were minutes in bed; minutes asleep; time until sleep onset; minutes in each of the stages 1, 2, 3, 4, and REM; minutes scored as movement time; latency to the first

REM period; and REM periodicity.

Sleep onset was defined as time elapsed from lights out until the subject remained in stage 2 sleep for 5 consecutive minutes. REM latency was defined as time elapsed from sleep onset until the first REM period of at least 2 consecutive minutes. REM periodicity was defined as the average time between the beginning of each REM period that was at least 2 minutes in length.

The first 360 minutes of sleep from sleep onset was analyzed separately since this was the longest common length of time for every subject on every night. These data were then divided into two data sets of 180 minutes each in order to analyze each half of the night. The first non-REM sleep period was analyzed separately in order to determine if the first sleep cycle of the night was affected by the heat. Finally, the data from the entire night were analyzed in less detail since each subject was allowed to determine his own bedtime. These analyses were done in order to allow adequate comparisons to the results of similar studies conducted in the past by other investigators (2).

Each of the variables from each set of data was analyzed with a repeated measures analysis of covariance. After graphing the data and conducting several preliminary analyses, it was decided that two covariates were needed in order to capture the effects of the conditions; one covariate was the difference in temperature between the baseline reading at the beginning of the treadmill test and the last temperature reading at the end of the flight, and the other covariate was the duration of the flight. Whenever the sphericity assumption was violated, the Greenhouse-Geisser adjusted probability levels were used. Significant effects were analyzed using the Newman-Keuls post hoc analysis. Table 1 gives summary statistics for the two covariates. Tables 2 through 4 give summary statistics for the 360-minute data set, each of the 180-minute half night data sets, and the whole night

data set.

6   RESULTS

The effects seen consistently in the data analysis were in REM sleep. The analysis of REM sleep for the 360 minute data set indicated an effect among the conditions ($F(6,40) = 2.39$, $p = .0455$). Post hoc analysis indicated the 41° liquid cooling condition was associated with significantly less REM sleep than the 35° liquid cooling condition ($p < .01$), the baseline condition ($p < .01$), and the 35° air cooling condition ($p < .05$). (See Figure 1.)

The first half of the night, but not the second half, showed a significant difference among the means for REM sleep ($F(6,40) = 2.60$, $p = .0320$). Post hoc analysis indicated the 41° liquid cooling condition was associated with significantly less REM sleep during the first half of the night than the baseline condition ($p < .01$), the 41° no cooling condition ($p < .01$), the 35° air cooling condition ($p < .01$), and the 35° liquid cooling condition ($p < .05$). (See Figure 2.)

Additionally, the full night data showed a significant difference among the means for REM sleep ($F(6,40) = 2.67$, $p = .0283$). Post hoc analysis revealed the 35° liquid cooling condition ($p < .05$), the 35° no cooling condition ($p < .05$), the 41° air cooling condition ($p < .01$), and the 41° liquid cooling condition ($p < .01$) was associated with significantly less REM sleep than the 41° no cooling condition. Also, the 41° liquid cooling condition was again associated with significantly less REM sleep than the baseline condition ($p < .01$), the 35° air cooling condition ($p < .01$), the 35° liquid cooling condition ($p < .05$), the 35° no cooling condition ($p < .05$), and the 41° air cooling condition ($p < .05$). (See Table 2.)

REM periodicity averaged over the entire night also was significantly affected by the conditions ($F(6, 40) = 2.64$, $p = .0298$). Post hoc analysis revealed the 35° air cooling condition produced a longer average

period between REM cycles than the 41° liquid cooling condition ($p <$ .05), the 35° no cooling condition ($p < .05$), and the 41° no cooling condition ($p < .01$).

No significant effects were found for any of the other variables, but there was a tendency for a difference in the amount of Stage 2 during the first non-REM period ($p = .0709$). The 41° no cooling condition and the 41° liquid cooling condition tended to produce more stage 2 sleep than the baseline condition and the 41° air cooling condition. See Tables 2 through 5 for summary statistics of the sleep stages from each data set.

7   DISCUSSION

The most pervasive effect seen in the present study was a decrease in REM sleep, in the first 360 minutes after sleep onset, the first 180 minutes of sleep after sleep onset, and in the full night data. However, SWS was not significantly affected by the heat conditions as was expected based on previous studies.

Although the length of the first REM period was not significantly different among the conditions, it is interesting to note that three of the eight subjects completely missed their first REM period, an effect also found in previous studies (2, 3). One subject was affected on three of the nights, while the other subjects were affected on only one night. No one particular condition was common for each of the nights in which these subjects missed their first REM period. However, it was found the nights on which the first REM period was missed tended to occur after a rise in core body temperature of at least 0.9°C (range = 0.9 to 1.8) and a flight duration of at least 82 minutes (range = 82 to 360) except for one subject. His core body temperature rose less than 0.1°C and his flight duration was 360 minutes.

The effect of flying a helicopter while wearing chemical protective clothing, either with or without cooling, on sleep appeared to be affected by two factors: 1) the length of time the pilot flew the simulator, and 2) the rise in core body temperature over the length of the test period (See Figure 3). Neither of these two factors alone significantly affected the sleep parameters, but combined, they showed a significant effect on sleep. The rise in core body temperature of approximately 1°C from baseline combined with at least 5 hours of flying the simulator was related to the subsequent night's decrease in REM sleep. When the pilot flew the simulator without experiencing a rise in core body temperature, or if the core body temperature rose to above 1.5°C over baseline values, but the pilot did not remain in this stressful environment more than 2 hours, no effects were seen during the subsequent night's sleep.

The fact that an increase in core body temperature alone was not sufficient to produce significant effects on sleep differed with the findings of previous studies. The flight during which core body temperature rose 1.7°C over an average of 77 minutes (41° no cooling) was not associated with significant effects on sleep. Contrary to the findings from previous studies where core body temperature was increased 1.5°C over a period of 1.5 hours, SWS in this study was not increased in the 41° cooling condition even though core body temperature was increased significantly. This discrepancy may have been due to differences between the length of time between heat stress and bedtime. In the present study, the heat stress occurred 10 hours or more before bedtime, and at least one earlier investigation showed that body heating more than 8 hours before bedtime did not significantly affect sleep (3). If the heat stress in the present study had occurred closer to bedtime, similar effects may have been found.

The condition which showed the most consistent effects on sleep was the 41° liquid cooling. During this condition, the average rise in core body temperature was 0.975°C (sd = 0.423), and the average flight duration was 354 minutes (sd =

16.971). The rise in core body temperature combined with a long flight duration was related to a significant decrease in REM sleep when compared to the baseline condition and both of the 35° cooling conditions in which the core body temperature rose 0.3°C or less and the flight duration was 346 minutes or more. Apparently, fatigue (due to a long flight) without heat stress did not affect sleep architecture.

In addition to the increase in REM sleep, visual inspection of the data for the 41° liquid cooling condition indicated that when SWS during the first 180 minutes after sleep onset is compared to REM sleep during the same period, there tended to be an inverse relationship in comparison to the other conditions. There was always more REM sleep than SWS in every condition except the 41° liquid cooling condition. Here, there was a tendency for more SWS than REM sleep. This effect supports previous studies which have found a decrease in REM sleep and an increase in SWS after passive heat. The decrease in REM sleep was attributed to an increased "pressure" for SWS (2). Although the present study did not find a significant rise in SWS in the 41° liquid cooling condition, the relationship between SWS and REM sleep was different from the relationship in those conditions which were not associated with a decrease in REM sleep. (See Figure 2.)

The implications of the present study are that pilots who are required to fly their aircraft in high heat environments where their core body temperature is elevated for long periods of time may experience sleep disruption following the flight. Apparently, heat stress in combination with long flights produces a change in normal sleep architecture, leading to a deeper than normal sleep after a day in which heat stress and long flights occurred. The effects of the heat stress may be more apparent if the heat stress occurs close to bedtime. Pilots who fly under lengthy periods of heat stress should be made aware that their subsequent sleep may be deeper than usual, making awakening more difficult.

8   ACKNOWLEDGEMENTS

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Table 1. Difference in temperature and flight duration (means and standard deviations).

	Baseline	35 Nil	35 Air	35 Liquid	41 Nil	41 Air	41 Liquid
Temp difference*	0.17	1.21	0.38	0.19	1.79	0.96	0.98
	(0.31)	(0.33)	(0.34)	(0.24)	(0.33)	(0.55)	(0.42)
Flight duration	360.00	290.88	346.13	360.00	76.88	343.13	354.00
	(0.00)	(94.11)	(39.24)	(0.00)	(21.12)	(47.73)	(16.97)

* Temperature difference = Final temperature at end of flight - beginning temperature at treadmill

Table 2. Full night data sleep parameters (adjusted means from covariate analysis).

	Baseline	35 Nil	35 Air	35 Liquid	41 Nil	41 Air	41 Liquid
Sleep onset	22.68	33.59	18.52	19.60	27.07	41.30	31.43
Sleep period	418.39	407.38	423.13	409.83	438.94	411.19	404.57
Total sleep time	410.77	388.00	410.70	408.30	414.95	394.89	366.34
Length first REMP	21.45	9.91	23.40	20.14	-6.05	12.18	15.64
REM latency	40.05	82.92	38.11	49.96	107.65	62.40	130.92
REM periodicity	106.18	91.95	126.06	103.62	84.46	97.59	92.13
Total REM	90.98	79.72	89.65	84.98	113.93	77.36	58.80
Total non-REM	323.81	305.64	324.26	327.26	294.55	316.52	306.46

Table 3. Sleep data from 360 minute period (adjusted means from covariate analysis).

	Baseline	35 Nil	35 Air	35 Liquid	41 Nil	41 Air	41 Liquid
Wake + movement	4.58	18.50	10.67	-0.51	21.13	14.81	36.12
Stage 1	50.71	45.98	57.58	52.76	38.05	41.69	52.91
Stage 2	213.83	211.93	209.52	221.50	218.30	205.80	199.30
Stage 3	17.66	14.81	17.73	11.54	10.30	20.69	15.78
Stage 4	0.26	0.08	0.19	0.07	0.24	0.29	0.12
SWS	17.95	14.88	17.94	11.64	10.40	21.01	15.93
REM	78.00	63.33	71.55	80.76	65.69	68.43	50.61

Table 4. Sleep data from each half of the night (adjusted means from covariate analysis).

	Baseline	35 Nil	35 Air	35 Liquid	41 Nil	41 Air	41 Liquid
First 180 min							
Wake + movement	1.36	11.86	6.13	-1.92	15.37	8.52	25.55
Stage 1	24.68	19.86	25.82	23.18	18.00	17.91	21.61
Stage 2	102.70	109.52	107.75	121.59	113.77	104.85	101.13
Stage 3	16.31	14.51	13.51	9.70	7.82	19.17	14.73
Stage 4	0.26	0.08	0.19	0.07	0.24	0.29	0.12
SWS	16.60	14.58	13.73	9.80	7.93	19.48	14.87
REM	35.87	22.45	28.65	28.48	28.70	24.81	13.84
Second 180 min*							
Wake + movement	5.11	6.52	5.02	2.05	6.55	6.82	11.24
Stage 1	26.44	25.74	32.10	29.97	20.13	23.40	30.84
Stage 2	112.07	102.09	102.49	100.84	101.23	101.39	98.76
Stage 3	1.03	0.50	3.96	1.53	3.05	1.58	1.10
REM	40.78	41.63	41.84	50.94	40.01	43.63	36.73

* No Stage 4 was scored for this half

Table 5. Sleep data from first non-REM period (adjusted means from covariate analysis).

	Baseline	35 Nil	35 Air	35 Liquid	41 Nil	41 Air	41 Liquid
Wake + movement	-8.22	10.25	-5.20	-8.31	20.99	6.42	29.14
Stage 1	6.36	6.50	5.66	8.32	9.47	5.51	10.69
Stage 2	42.46	47.76	49.52	52.81	57.92	43.05	54.11
Stage 3	6.39	7.45	6.75	3.06	8.51	10.02	6.51
Stage 4	0.02	0.01	0.07	0.02	0.23	0.17	0.05
SWS	6.51	7.40	6.91	3.18	8.50	10.19	6.57

Figure 1. REM and slow wave sleep from the first 360 minutes after sleep onset.

☐ REM sleep ☑ Slow wave sleep
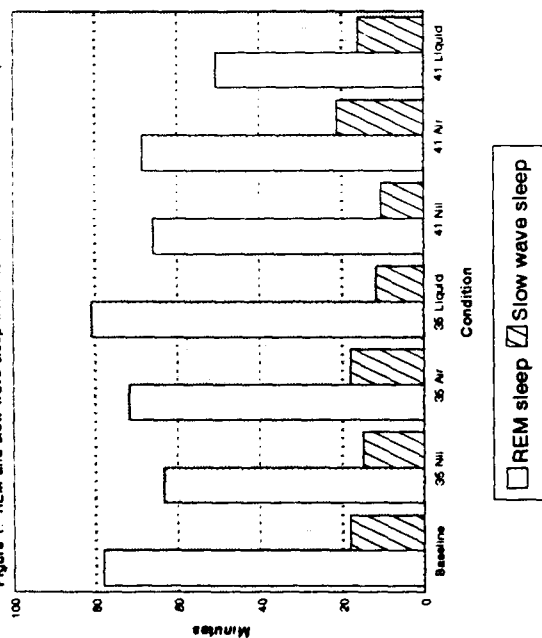
Figure 2. REM and slow wave sleep from the first 180 minutes after sleep onset.

☐ REM sleep ☑ Slow wave sleep
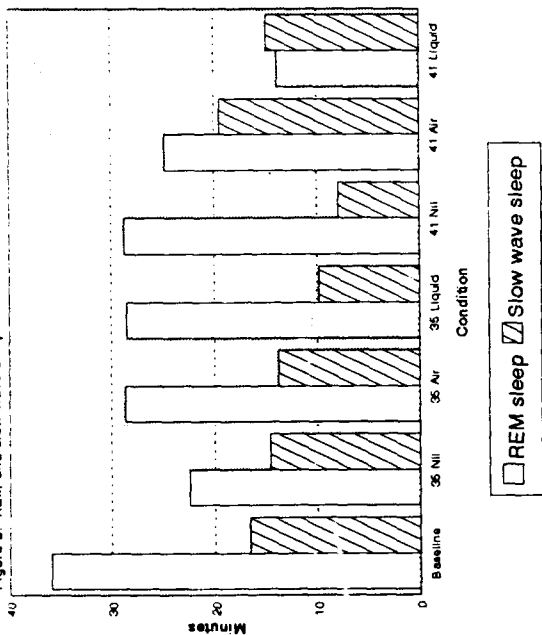
Figure 3. Flight duration and rise in core body temperature.

☐ Flight duration ☑ Temperature difference
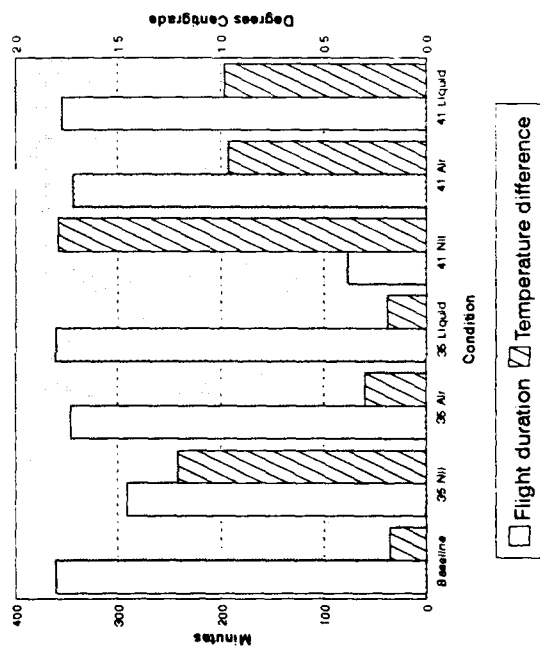
FACTEURS HUMAINS ET SECURITE DES VOLS: IMPORTANCE DE LA GESTION DU SOMMEIL

par

Ph. Cabon, R. Mollard et A. Coblentz
Laboratoire d'Anthropologie Appliquée
URA 220 CNRS
UFR Biomédicale — Université R. Descartes
45 rue des Saints Peres
75270 Paris Cedex 06
France

J.P. Fouillot
Laboratoire de Physiologie des Adaptations
Université R. Descartes
Paris
France

J.J. Speyer
Airbus Industrie
Toulouse
France

1. INTRODUCTION

Dans le domaine du transport aérien civil, la fatigue et le sommeil des pilotes deviennent de plus en plus des préoccupations sur le plan de la sécurité des vols, notamment pour les vols long-courriers. En effet, ces vols entraînent des contraintes importantes pour les pilotes : décalages horaires rapides et multiples, travail de nuit ou à horaires décalés avec des amplitudes de services parfois très élevées. L'effet cumulé de ces contraintes entraîne des perturbations des rythmes circadiens et des privations de sommeil réduisant la performance et le niveau d'éveil des pilotes (Graeber, 1986 ; Nicholson, 1986 ; Mollard et coll., 1990 ; Cabon et coll., 1991). Ces difficultés se trouvent particulièrement accrues par l'allongement de la durée des vols avec les avions modernes du type Boeing 747-400 et Airbus A340 (vols de durées pouvant atteindre 14 heures). Ces vols qui restent pour l'instant limités à certains types de routes vont tendre à se généraliser dans un proche avenir. Ils sont réalisés avec un équipage renforcé, la réglementation française de l'aviation civile interdisant le travail d'un pilote au-delà d'une période de 8 ou 10 heures selon le type d'appareil. L'apparition, relativement récente, de ces aéronefs pose la question très délicate de la gestion du sommeil pour l'ensemble de l'équipage, au cours de l'escale et au cours du vol.

A ces contraintes physiologiques, il faut ajouter les modifications de l'activité de pilotage dans les avions modernes. L'automatisation croissante des cockpits contribue parfois à rendre très monotones les tâches du pilote ainsi qu'à réduire considérablement les sollicitations sensorielles (Graeber, 1989 ; Roscoe, 1989 ; Cabon et coll., 1991).

Des travaux similaires ont été également conduits dans le domaine militaire (Lagarde, 1991).

L'action cumulée de ces deux facteurs, perturbations du sommeil et monotonie de l'activité est susceptible d'entraîner des états d'hypovigilance qui peuvent se révéler, dans certaines circonstances préjudiciables à la sécurité du vol.

Cet article rapporte les résultats d'une recherche visant à étudier la durée et la qualité du sommeil des équipages d'avions civils au cours de rotations comprenant des vols long-courriers de durées égales ou supérieures à 8 heures.

2. METHODE

Au cours de cette recherche, la durée et la qualité du sommeil ont été évaluées par un enregistrement de l'activité motrice (actométrie) à partir d'un enregistreur fixé au poignet des pilotes tout au long de la rotation. Le capteur utilisé (Actigraph), d'un poids d'environ 80 g comprend un accéléromètre et une centrale d'acquisition numérique qui comptabilise les mouvements par période de 30 secondes. Ces enregistrements, complétés par les informations subjectives et l'observation des pilotes en vol, permettent l'évaluation de deux aspects essentiels qui déterminent le niveau d'éveil des pilotes au cours de l'activité :
- la durée et la qualité du sommeil à l'escale,
- la durée et la qualité du sommeil à bord pour les vols de durées supérieures à 8 heures. Deux rotations de ce type ont été étudiées : la première vers l'ouest, Paris-San Francisco, la seconde vers l'est, Paris-Singapour.

Au cours des vols étudiés, des enregistrements d'électro-encéphalographie (EEG), d'électro-oculographie (EOG) et de fréquence cardiaque étaient également réalisés dans le but d'étudier les variations des états de vigilance au cours du vol (EEG et EOG) et permettre un calcul a posteriori de la charge de travail des pilotes avec le modèle Airbus (fréquence cardiaque). Seules les données portant sur le sommeil sont présentées dans cet article. Les résultats des variations de vigilance en vol sont rapportés dans d'autres publications (Fouillot et coll., 1991; Speyer et coll., 1991 ; Coblentz et coll., 1991; Cabon et coll., 1991 ; Cabon, 1992).

L'analyse des durées de sommeil porte sur la comparaison de quatre types de rotations et sur un échantillon de 22 pilotes. Les rotations peuvent être considérées comme représentatives de situations différentes, aussi bien pour ce qui concerne le type d'appareil que sur le plan du décalage horaire :
- rotations Bruxelles - New York - Bruxelles ou Bruxelles - Boston - Bruxelles -(GMT-5) sur Airbus A310 (environ 8 heures de vol),
- rotations Bruxelles-Libreville-Bruxelles (GMT+1) sur Airbus A310 (environ 7 heures de vol),
- rotations Paris-San Francisco-Paris (GMT-8) sur DC10 (environ 11 heures de vol),
- rotations Paris-Singapour-Paris (GMT+7) sur B747-400 (environ 12 heures de vol).

La durée d'escale au cours de ces rotations est comprise entre 24 et 48 heures.

3 . RESULTATS

3.1 - Repos et durée du sommeil à l'escale.

La comparaison des durées de sommeil au cours des escales montre un effet très important des privations de sommeil subies à la suite des vols vers San Francisco et Singapour par rapport aux rotations Bruxelles-New York ou Boston et Bruxelles-Libreville. Cet effet se traduit par un effet rebond sur la durée du sommeil (figure n°1) qui atteint en moyenne 11h37 à Singapour et 11h12 à San Francisco. Ces durées sont très élevées par rapport à des durées moyennes normales qui se situent aux alentours de 8 heures, ce qui a pu être constaté aux escales de New York ou Boston (7h45). Au cours des escales à Libreville, une durée de sommeil plus importante (9h40) a été constatée. Ces résultats peuvent s'expliquer par l'action cumulée de plusieurs facteurs.

Le premier facteur concerne l'heure à laquelle se déroule le vol aller. Les vols vers San Francisco et Singapour se déroulent la nuit alors que les vols vers New York, Boston ou encore Libreville se déroulent au cours de la journée. Dans les premiers cas, les pilotes subissent une privation de sommeil nocturne importante, apparemment non compensée par les repos en vols. On constate des durées totales de sommeil à l'escale plus importantes à Libreville qu'à New York et Boston pour la raison suivante : le vol retour se déroule de nuit et les pilotes se préparent à ce vol par une sieste d'environ deux heures en milieu d'après-midi, ce qui ramène la durée du sommeil à environ 7h40.

Le second facteur susceptible d'intervenir dans ces durées de sommeil correspond à l'action d'une substance hypnogène qui s'accumulerait d'autant plus que le sujet résiste plus longtemps à la pression du sommeil (Lavie, 1989). Ce facteur doit probablement être évoqué en raison des veilles prolongées observées au cours des vols San Francisco et Singapour, ce qui n'est pas le cas pour les vols vers New York ou Boston et Libreville.

Cette analyse serait incomplète si la qualité du sommeil n'était pas prise en compte. Cette qualité peut être évaluée par différents moyens. Dans des enregistrements polygraphiques de sommeil en laboratoire, il est possible d'évaluer son architecture en étudiant les durées de ses différents stades, les stades les plus profonds (stades 3, 4 et sommeil paradoxal) étant considérés comme ceux permettant la meilleure récupération par rapport aux stades légers (stades 1 et 2). Dans le type de travail rapporté ici, de tels enregistrements sont impossibles. Nous devons nous limiter au recueil de l'activité motrice au cours du sommeil. Ceci permet en particulier de déterminer le nombre d'éveils survenant au cours du sommeil, appelés éveils persomniques. Plus le nombre de ces éveils est important, moins la durée des stades profonds est élevée. Afin de rendre compte de cette qualité, un indicateur de la fragmentation du sommeil (F) a été calculé sur la base du nombre de périodes de sommeil interrompues par des éveils persomniques. Un sommeil dont la valeur est noté 1 peut être considéré de bonne qualité, alors qu'un sommeil noté 2 ou 3 sera considéré de mauvaise qualité puisque interrompu par des éveils persomniques. Le calcul de cet indicateur F confirme les difficultés de sommeil des pilotes au cours des escales à San Francisco et Singapour (cf figure n°1). Pour ces deux escales, la valeur F est supérieure à 2 alors qu'elle est inférieure à 2 pour les sommeils enregistrés au cours des escales à New York ou Boston et à Libreville. Cette différence dans la qualité du sommeil au cours des escales réside probablement dans l'heure à laquelle se déroulent ces sommeils. Les escales à Libreville, New York et Boston se déroulent au cours de la nuit, le sommeil débutant dans une "porte du sommeil" (Lavie, 1989), ce qui se traduit non seulement par des durées normales mais aussi par une qualité de sommeil satisfaisante. L'escale de Singapour permet également aux pilotes de s'endormir dans une "porte du sommeil" située en début d'après-midi, heure de Paris, les pilotes ne subissant pas de désynchronisations importantes compte tenu de la faible durée de l'escale. Cependant ce sommeil se prolonge jusqu'à des zones dites "interdites" pour le sommeil, situées en fin d'après-midi, ce qui explique les nombreux éveils persomniques. Pour ce qui concerne le sommeil à San Francisco, il débute vers le début de matinée qui constitue également une période défavorable

pour l'endormissement, ce qui se manifeste par une mauvaise qualité du sommeil.

3.2 - Repos et durée du sommeil au cours du vol.

L'analyse des repos et des durées de sommeil ne porte que sur les vols dont la durée dépasse 10 heures, avec équipage renforcé, vers San Francisco et Singapour. Cette analyse porte sur les durées et qualités moyennes de sommeil :
- pour l'ensemble des équipages enregistrés,
- selon la fonction à bord (commandant de bord, copilotes et mécanicien),
- selon l'heure du repos dans le vol.

3.2.1 Durées et qualité moyenne du sommeil pour l'ensemble des équipages enregistrés

Le premier fait marquant concerne la différence dans la durée moyenne de sommeil au cours du vol entre l'aller et le retour (figure n°2). Les durées sont plus élevées au cours de l'aller pour les rotations vers Singapour et San Francisco. Ce premier résultat s'explique par les durées de sommeil très élevées au cours de l'escale évoquées précédemment. Il a été montré (Karacan et coll., 1970 ; Akerstedt, 1989) que des durées importantes de sommeil affectent la durée de la période de sommeil suivante. Les pilotes ayant beaucoup dormi à l'escale, rencontrent des difficultés d'endormissement au cours du vol retour.

La différence entre les durées de sommeil au cours des vols vers San Francisco et celles vers Singapour constitue le second résultat important qui ressort de cette analyse. Les pilotes dorment beaucoup plus au cours des vols vers San Francisco effectués sur DC10 qu'au cours des vols Singapour réalisés sur Boeing 747-400. Il s'agit d'un résultat paradoxal dans la mesure où le Boeing 747-400 dispose de couchettes réservées aux pilotes et au mécanicien, ce qui n'est pas le cas pour le DC10. Trois interprétations peuvent être évoquées pour tenter d'expliquer ces données:
- la première réside dans la composition de l'échantillon, avec d'éventuelles différences individuelles dans la durée du sommeil. Pour chacun de ces deux types de vols, les membres de l'équipage ayant participé à la recherche étaient a priori peu différents les uns des autres : personnel entraîné, d'âge identique. On peut donc penser que l'effet observé s'explique par le fait que les pilotes des vols Singapour sont des petits dormeurs et que les pilotes des vols San Francisco sont des gros dormeurs. Cependant les durées de sommeil sensiblement équivalentes au cours des escales (cf. figure n°1), contredisent en partie cette hypothèse,
- la deuxième explication réside dans la traversée des méridiens et dans la présence ou

l'absence de la lumière du jour dont l'effet perturbateur sur le sommeil est bien connu. Au cours des vols Paris-San Francisco et San Francisco-Paris, la lumière du jour demeure absente, ce qui n'est pas le cas pour le vol Paris-Singapour. Cependant le vol retour de Singapour s'effectue également sans lumière du jour avec pourtant des durées de sommeil très faibles. Cette explication ne peut donc s'appliquer que partiellement à ces données,
- enfin, la troisième explication concerne davantage le confort, l'insonorisation des sièges et des couchettes réservés au sommeil des pilotes. Dans le Boeing 747-400 en exploitation au cours de cette recherche, la proximité des couchettes et des toilettes dont on a pu constater le bruit important provoqué par les toilettes fonctionnant par aspiration, perturbe le sommeil des pilotes. En ce qui concerne le repos sur DC10, les pilotes se reposaient sur des sièges de première classe, avec finalement un environnement sonore plus acceptable.

Il est difficile d'affirmer laquelle de ces trois interprétations explique le mieux les résultats constatés. Il est probable qu'elles possèdent une action conjuguée.

3.2.2 Durées moyennes du sommeil au cours du vol selon la fonction à bord.

Les résultats présentés dans ce chapitre ont été obtenus sur un échantillon numériquement faible, et leur interprétation doit être considérée avec prudence. Pour les vols sur San Francisco, les enregistrements ont été réalisés uniquement sur les CM1 (commandant de bord), CM2 (copilote) et CM3 (mécanicien navigant). Pour les vols sur Singapour, trois CM4 (copilotes en renfort) ont participé à l'étude.

Les résultats (figure n°3) indiquent cependant plusieurs tendances intéressantes :
- pour les vols vers San Francisco, la durée de sommeil en vol semble bien répartie pour l'ensemble des pilotes, notamment au cours du vol aller,
- au cours des vols vers Singapour, cette répartition paraît moins bonne, avec des durées inférieures à 2 heures pour les CM1 et CM2, à l'aller comme au retour.

Ces résultats montrent que pour les vols Singapour, les durées moyennes de sommeil restent très faibles pour l'ensemble de l'équipage. Ceci s'explique certainement par un déficit de sommeil touchant sélectivement les CM1 et CM2. Les CM2 et CM4 ayant les mêmes charges à bord, ces différences s'expliquent probablement par des différences individuelles dans les besoins de sommeil. Pour ce qui concerne

les rotations San Francisco, ce résultat confirme la bonne gestion du sommeil au cours des vols. Un autre élément doit être pris en compte : on en est au tout début des vols très long-courriers tels que Paris-Singapour et les équipages manquent d'expérience quant à la façon d'organiser le repos au cours de ces vols. C'est dire toute l'importance d'une réflexion sur l'organisation du travail en sachant d'ailleurs qu'il n'y aura pas une solution, mais au contraire plusieurs scénarios prenant en compte la diversité des membres de l'équipage.

3.3 - Durées du sommeil selon l'heure du repos au cours du vol.

L'un des facteurs essentiels susceptibles de faire varier la durée de sommeil des pilotes au cours des vols de durées supérieures à 12 heures, concerne la période du repos au cours du vol. Ce facteur est lié à la fatigue, à la durée de privation de sommeil ainsi qu'aux variations circadiennes de la durée du sommeil. Les figures n 4 et 5 montrent la répartition des durées de repos relevées au cours de nos observations (le pilote sort du cockpit pour s'installer dans l'aire de repos) et des durées de sommeil évaluées par l'actométrie, l'EEG et l'EOG au cours des vols vers Singapour. Première constatation : selon l'heure à laquelle survient la période de repos, le sommeil ne présente pas la même durée. Plus la période de repos survient tardivement au cours du vol, plus la durée du sommeil est élevée. Par ailleurs, on ne retrouve pas toujours une simultanéité entre le repos et le sommeil. Par exemple le CM4 sur le vol XX09 est caractérisé par des alternances de somnolence et de sommeil léger entre 5h00 et 8h30 dans le cockpit, alors qu'il s'est reposé entre 23h50 et 4h50 dans l'aire de repos, spécialement aménagée à cet effet, sans présenter de périodes de sommeil. Il en est de même pour le CM2, sur le vol XX10 entre 0h55 et 4h10. En dehors de ces deux cas extrêmes dans lesquels les pilotes ne peuvent être considérés comme efficaces pendant la majorité du temps de vol, on peut remarquer assez souvent que les moments choisis pour les périodes de repos ne permettent pas un endormissement rapide. C'est le cas du CM2 au cours du vol XX09 aller. Ces résultats confirment les difficultés provoquées par l'organisation du travail au cours de ces vols. Les périodes de repos ne peuvent pas toujours être prises en fonction d'un besoin de sommeil mais plutôt en fonction d'une organisation prévue à l'avance, permettant en théorie de ne défavoriser aucun des membres de l'équipage. Dans les faits, on constate que les pilotes favorisés sont ceux dont la période de repos coïncide avec un moment où la pression du sommeil est importante.

Les figures n°6 et 7 présentent les résultats pour les vols San Francisco. On constate qu'au cours de ces vols, l'organisation des cycles activité-repos est différente de celle pour les vols sur Singapour. La différence essentielle repose dans le fait que les périodes de sommeil sont beaucoup plus fragmentées, indiquant que les pilotes prennent leur repos lorsque la pression du sommeil augmente. Cette organisation se traduit par des durées moyennes de sommeil plus élevées que pour les vols sur Singapour, et des périodes de sommeil qui se situent effectivement au cours des repos.

4. CONCLUSION

Plusieurs facteurs comme le travail à horaires décalés et les décalages horaires sont susceptibles d'entraîner des perturbations des rythmes biologiques. L'automatisation des cockpits se trouve à l'origine d'altérations du niveau d'éveil au cours du vol. D'un point de vue opérationnel, ceci peut se traduire par une réduction de l'efficacité susceptible de mettre en cause la sécurité des vols lors de situations critiques.

La prise en compte des facteurs perturbant les rythmes biologiques et le rythme veille-sommeil devrait constituer une préoccupation essentielle afin de concevoir des solutions acceptables sur le plan opérationnel. L'une des solutions actuellement évoquées concerne la possibilité de siestes au cours du vol (Graeber, 1990). La plupart des études de laboratoire et en situation réelle indiquent que ces siestes permettent une récupération efficace et une meilleure resynchronisation des rythmes biologiques (Evans et Orne, 1975 ; Dinges et coll., 1981 ; Akerstedt et coll., 1989 ; Stampi, 1989). L'efficacité des siestes n'a pour l'instant été testée que sur des vols d'une durée maximale de huit heures. Des investigations restent à mener sur des vols dont la durée dépassent 12 heures afin de vérifier l'efficacité de procédures particulières de repos. Nous avons débuté une recherche de ce type avec les compagnies ayant déjà participé à cette campagne d'expérimentations. Plusieurs solutions sont évaluées pour aboutir à une meilleure gestion du sommeil à bord et aux escales ainsi qu'une limitation des baisses de vigilance simultanées des pilotes présents dans le cockpit. Les recommandations concernent la modulation de l'heure de réveil et de la sieste dans les 12 heures précédant le départ en fonction de la période de repos prévue en vol, la prise décalée des repas et une alternance de phases de veille active - veille non active. Les premières rotations effectuées entre Paris et Singapour ont permis de démontrer la faisabilité et l'intérêt de telles solutions.

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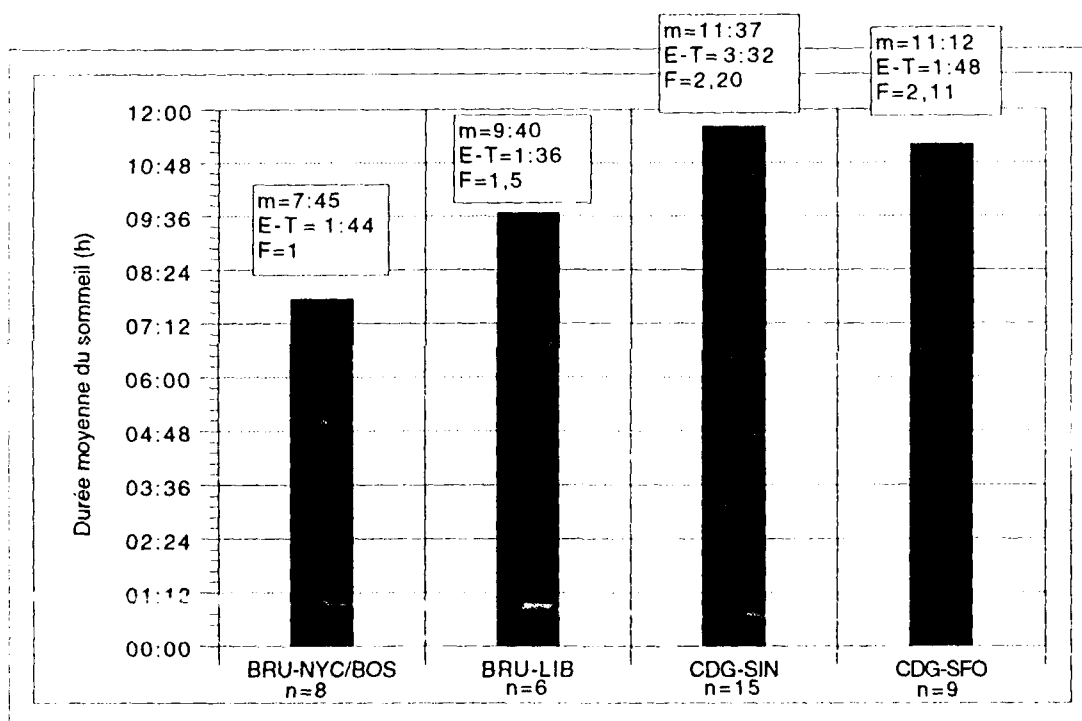
Figure n° 1 - Durées et qualité moyennes (F) de sommeil au cours des escales pour les rotations de Bruxelles (BRU) vers New York (NYC) ou Boston (BOS), Libreville (LIB), Singapour (SIN) et San Francisco (SFO).
La qualité du sommeil est évaluée en fonction de la fragmentation du sommeil. Plus le sommeil est fragmenté, plus le nombre d'éveils persomniques est élevé. La valeur F est donc obtenue en calculant la moyenne des périodes de sommeil. Plus cette valeur est élevée, moins la qualité du sommeil est bonne.
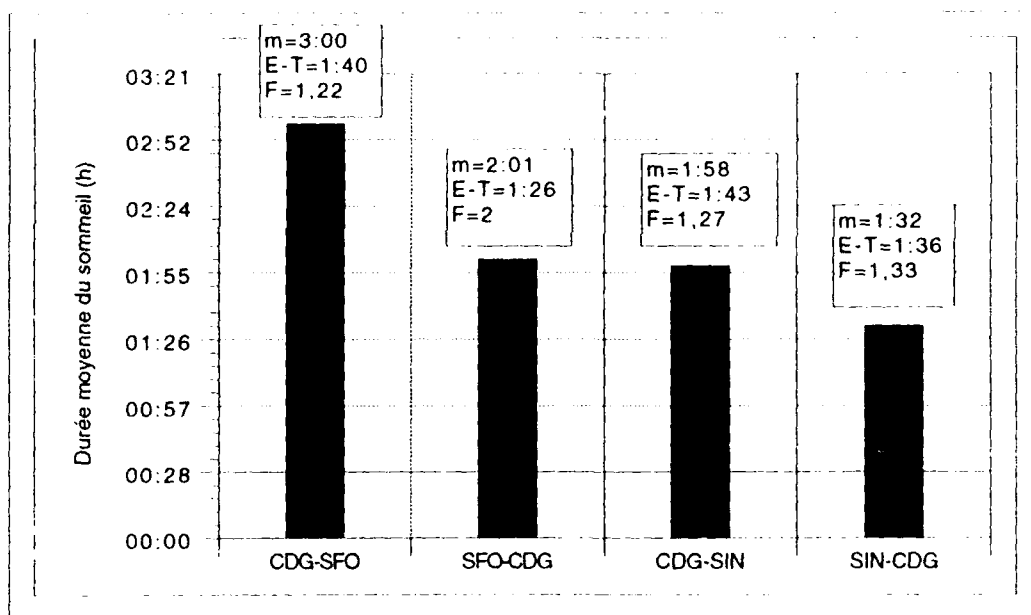
Figure n° 2 - Durées moyennes de sommeil au cours des vols Paris(CDG)- San Francisco (SF0) (n=9) et Paris (CDG)- Singapour (SIN) (n=15).

m = moyenne   E-T= écart-type   F= indice de qualité du sommeil
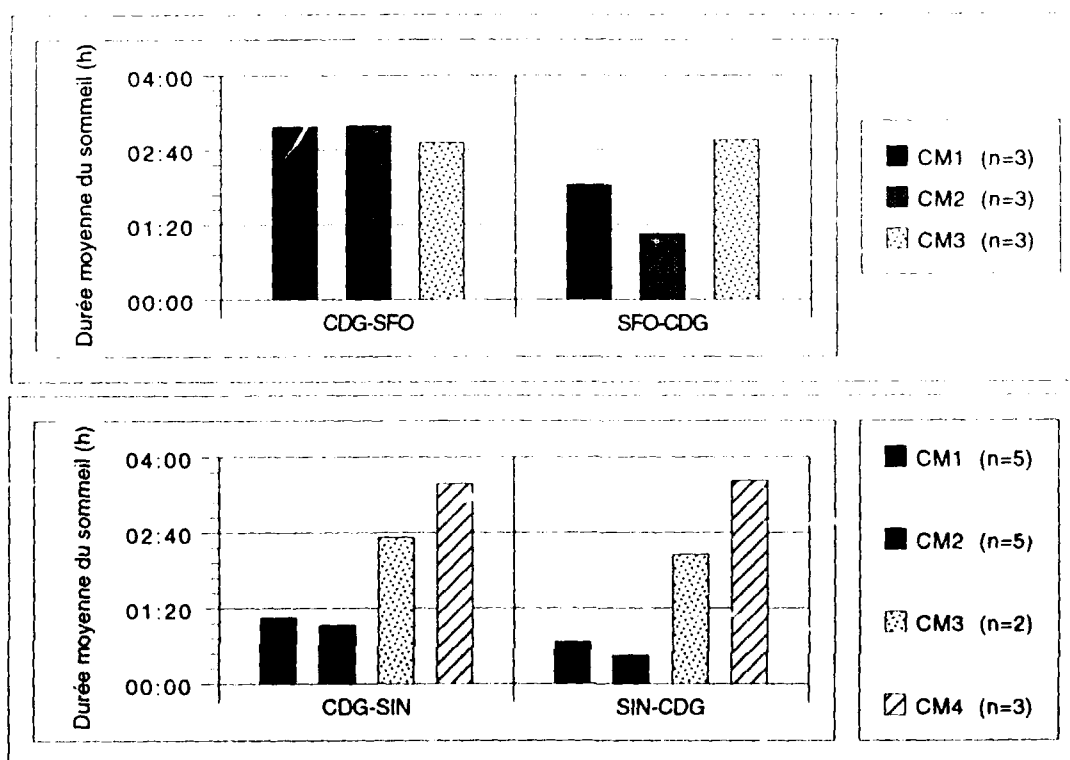
Figure n°3 - Comparaison des durées moyennes de sommeil au cours du vol entre les différents membres de l'équipage pour les vols Paris-San Francisco (en haut) et Paris-Singapour (en bas).
CM1 : Commandant de bord
CM2, CM4 : Copilotes
CM3 : Mécanicien navigant.
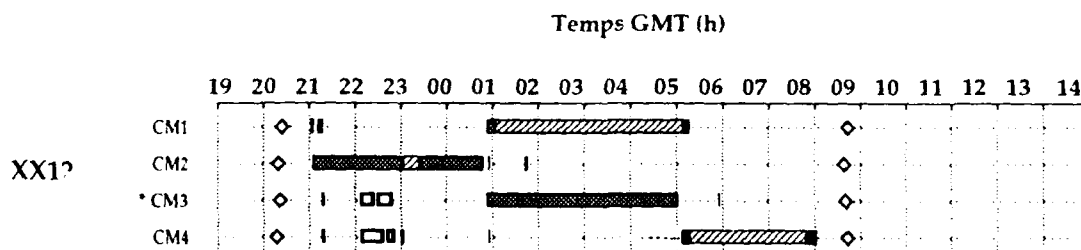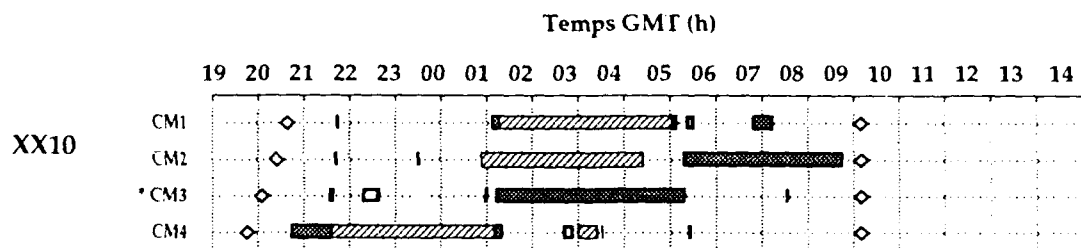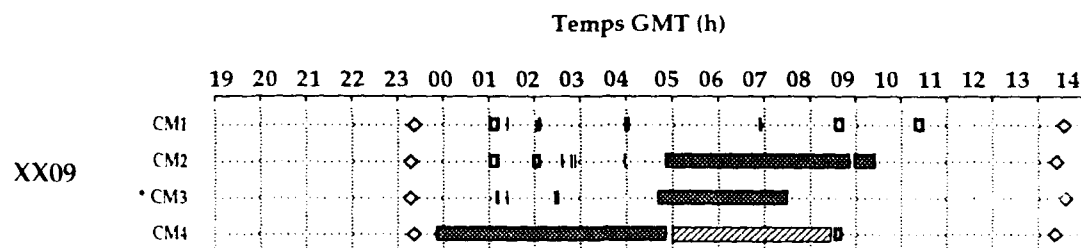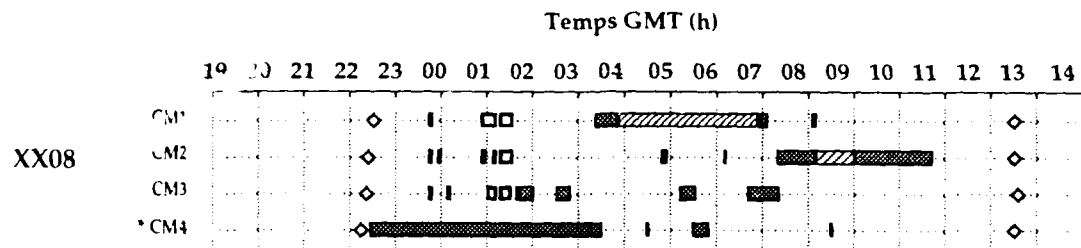
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PARIS - SINGAPOUR

Figure n°4. Périodes de repos, sommeil et repas au cours des vols Paris - Singapour.

CM1 : Commandant de bord
CM2, CM4 : Copilotes
CM3 : Mécanicien navigant

SINGAPOUR - PARIS
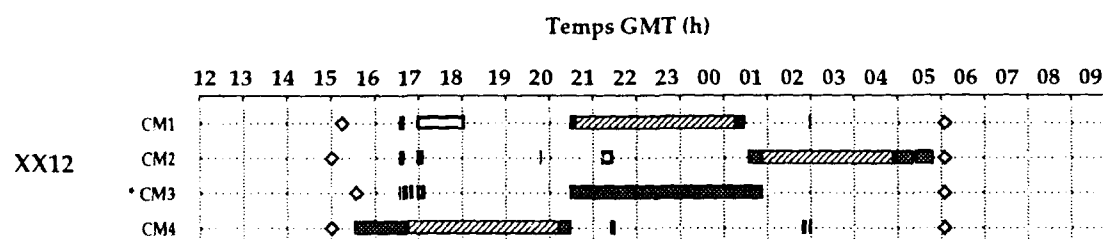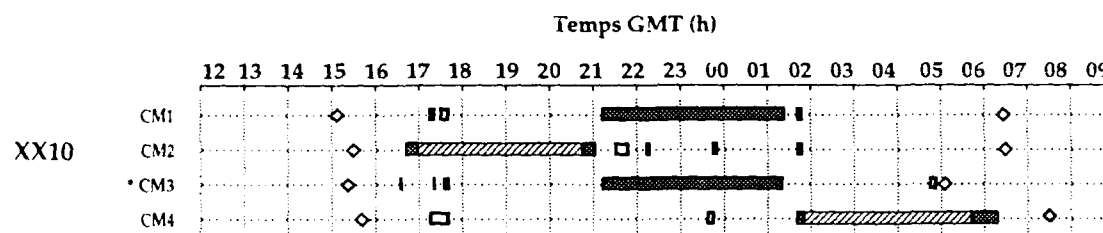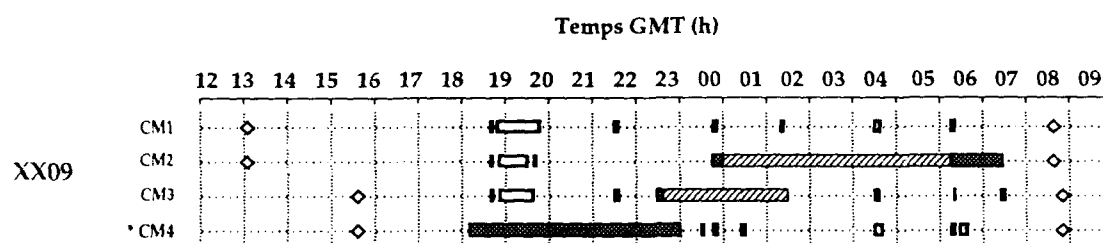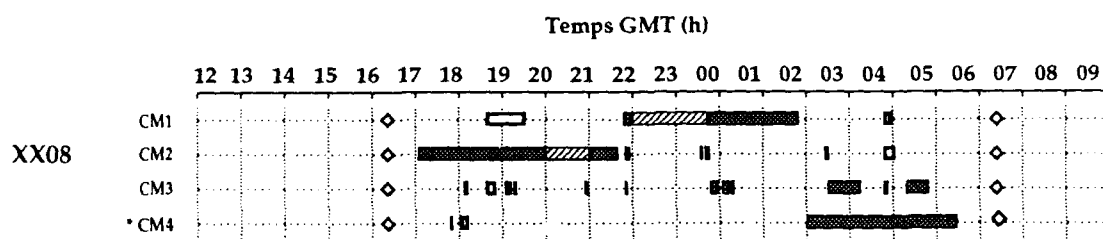
Figure n°5. Périodes de repos, sommeil et repas au cours des vols Singapour-Paris.

CM1 : Commandant de bord
CM2, CM4 : Copilotes
CM3 Mécanicien navigant

Légende:
- * Données actométrie absentes
- ■ Période de repos
- ▨ Durée sommeil
- ▭ ou ∎ Repas
- ◇ Début enregistrement / Fin enregistrement

PARIS - SAN FRANCISCO
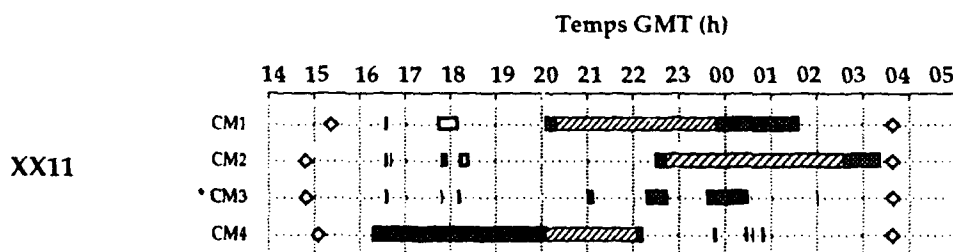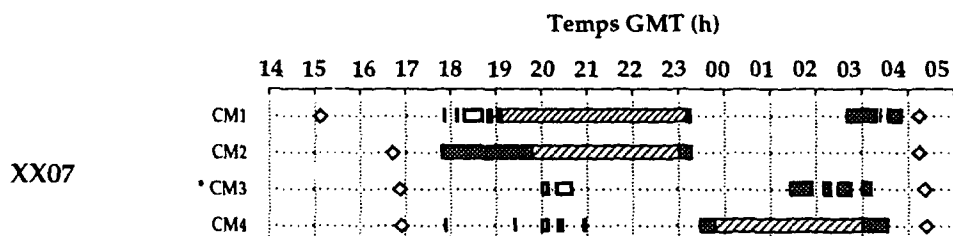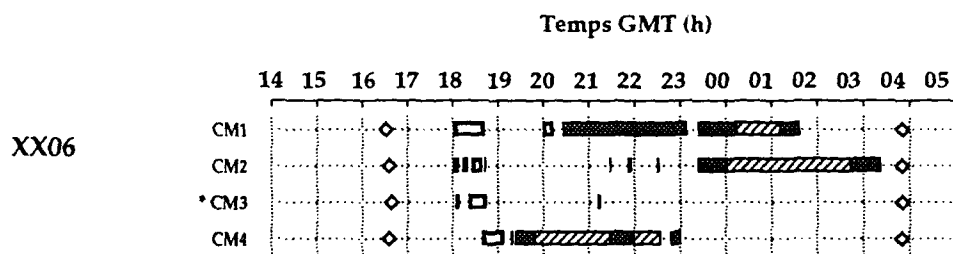
Temps GMT (h)

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* **Données actométrie absentes**
▬ **Période de repos**
▨ **Durée sommeil**
▭ ou ▪ **Repas**
◇ **Début enregistrement / Fin enregistrement**

Figure n°6. Périodes de repos, sommeil et repas au cours des vols Paris - San Francisco.
   CM1 : Commandant de bord
   CM2, CM4 : Copilotes
   CM3 : Mécanicien navigant

SAN FRANCISCO-PARIS
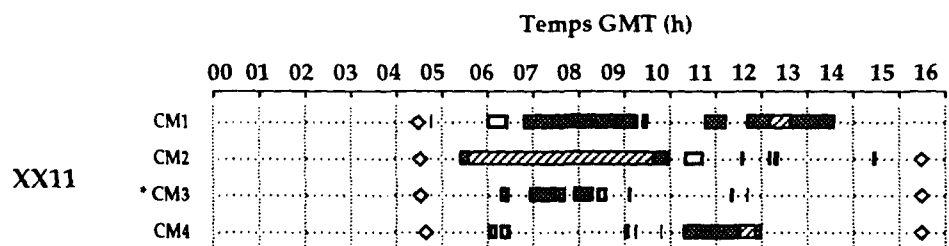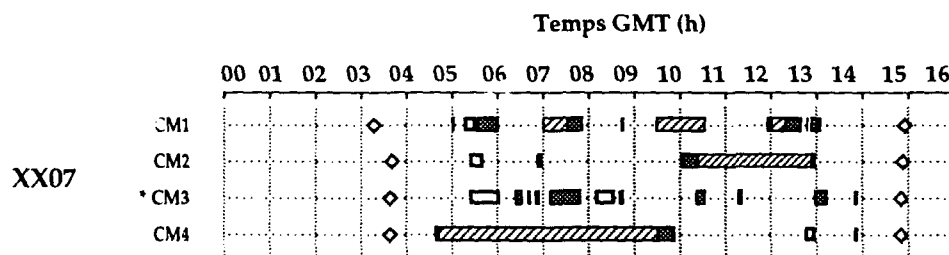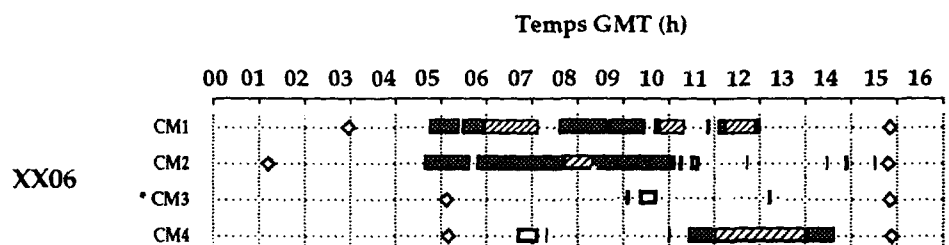
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Temps GMT (h)

*   **Données actométrie absentes**
▀   **Période de repos**
▨   **Durée sommeil**
▭ ou ▮ **Repas**
◇   **Début enregistrement / Fin enregistrement**

Figure n°7. Périodes de repos, sommeil et repas au cours des vols San Francisco-Paris.

CM1 : Commandant de bord
CM2, CM4 : Copilotes
CM3 : Mécanicien navigant

DIGITAL FLIGHT DATA AS A MEASURE OF PILOT PERFORMANCE ASSOCIATED WITH FATIGUE FROM CONTINUOUS OPERATIONS DURING THE PERSIAN GULF CONFLICT

Roger U. Bisson
Kelly J. Neville
Patricia A. Boll
Jonathan French
William R. Ercoline[1]
Robert L. McDaniel[2]
William F. Storm

Sustained Operations Branch, Armstrong Laboratory
Brooks Air Force Base, Texas, USA, 78235-5000

Krug Life Sciences[1]
San Antonio, Texas, USA, 78216

437 Military Airlift Wing[2]
Charleston Air Force Base, South Carolina, USA, 29404-5300

SUMMARY

The results of a field study using the C-141 Digital Flight Data Recorder (DFDR) to evaluate whether fatigue affected piloting precision during the Persian Gulf conflict are described. This is the first time digital flight data from the C-141 has been used to evaluate routine aircrew performance. Five C-141 military transport crews were granted scheduling priority to quickly accumulate 150 flight hours in less than 30 days. Fatigue estimates were based upon activity logs, fatigue ratings, oral temperature, and mood surveys. Eighty seconds of the instrument landing system (ILS) final approach above decision height were isolated from digital flight data downloaded after each flight. Both an average and a standard deviation were calculated for airspeed, heading, vertical velocity, pitch and roll for each of the 80 second ILS segments. The standard deviations served as estimates of piloting precision and were correlated to fatigue measures. No significant differences in piloting precision categorically attributable to fatigue were found. However, individual examples of decreased precision associated with high fatigue levels were observed. These deviations did not occur with enough regularity to conclude whether fatigue or other factors were the root cause. DFDR data can be a sensitive measure of perfor-mance, but the operational setting of Desert Storm did not permit control of important variables in this first time effort. The findings suggest that DFDR assessment of flying precision could be of value in controlled studies of fatigue, workload, or drugs that affect pilot performance. Future studies need to evaluate digital flight data versus other cognitive and psychomotor tasks that are sensitive to changes in performance.

1 INTRODUCTION

Operations Desert Shield and Desert Storm represent the most massive airlift campaign in military history. Within days of commencing Desert Shield, the maximum flying time limit of 125 hours per 30 consecutive days was waived to 150 hours over the same period. The unaugmented crew duty day remained at 16 hours although frequent extensions to 20 hours were granted. Occasionally, highly motivated crews requested even these 20-hour limits be extended for specific missions. Regulations defined crew duty day as beginning one hour after being alerted for a mission. Crew duty day usually ended with engine shut down (block time). Minimum crew rest remained at 12 hours. Crew rest began at the end of the duty day and included time for meals, trans-portation and the opportunity for eight hours of

continuous sleep (1). Crew and aircraft availability sometimes necessitated adjusting crew or aircraft schedules to avoid violating these limits, but in general crew rest requirements were closely adhered to and did not cause problems or long delays. This massive effort strained airlift resources to their limit. The Desert Shield fatigue study in August-September 1990 made some timely recommendations for fatigue management(2). However, after over seven months of continuous and sustained operations, a more definitive study was contemplated to preserve lessons learned and to improve fatigue management and flying safety, and to increase operating capabilities.

Fatigue is a potent and insidious enemy. Several mishaps involving loss of life or major aircraft damage during Desert Shield and Desert Storm identified fatigue as directly contributing to the mishap sequence. Except for the crew rest and flight duty limitations noted above, policy guidance on scheduling, alerting (time required for reporting and mission preparation), stage management (local sequencing of crews), and crew release (suspended during contingencies such as Desert Shield and normally limited to six hours in peacetime) was limited to Military Airlift Command (MAC) supplements to Air Force regulations (5). In general, the regulations provided adequate defense against this enemy, but did not provide offensive strategies for fatigue management.

The specific request to the Sustained Operations Branch at the Armstrong Laboratory relayed by the Military Airlift Command Surgeon was to study whether the extended 30-day flight hour limits were safe and if they were safe, could crew rest be better managed to optimize use of airlift assets.

The purpose of this portion of the study was to use the DFDR to acquire piloting performance data and on the basis of these data to assess whether cumulative flight hours, recent sleep history, length of duty day, circadian rhythm, or subjective fatigue affected the ability of pilots to safely fly a precision approach. Together with other findings, these measures were designed to permit inferences regarding management of crew fatigue, safety of flight, and operational plans for future conflicts.

2 METHODS

Volunteer aircrew were briefed on the study design and trained in using the various study instruments. Study instruments included subjective fatigue ratings (Table 1), daily activity logs, oral temperature (circadian rhythm), Profile of Moods States (POMS)(4), and sleep surveys. More detailed description of these study instruments and their use can be obtained from other reports of these data (2).

Pilots were instructed to manually fly approaches using instrument landing system (ILS) flight path guidance to the maximum extent possible. They were to fly each evaluated segment as precisely as possible using recommended technical procedures for course, airspeed, and altitude control. The pilot flying the aircraft was instructed to avoid transitioning to outside references prior to decision height (200 feet above ground level (agl) for most ILS approaches). Crews were encouraged to intercept the ILS final approach course as early as practical. Flight deck observers from the test team used an inflight data checklist to record details about each approach. Cockpit intercom and radio transmissions were recorded to supplement information on the inflight data checklists.

The C-141 Digital Flight Data Recorder (DFDR) receives a serial stream of data conditioned by the Flight Data Acquisition Unit (FDAU). The FDAU samples signals for 17 flight parameters in 4 second frames at a rate of 64 words per second.

TABLE 1: Subjective Fatigue Scale

1 - Fully Alert; Wide Awake; Extremely Peppy
2 - Very Lively; Responsive, but not at Peak
3 - Okay; Somewhat Fresh
4 - A Little Tired; Less than Fresh
5 - Moderately Tired; Let Down
6 - Extremely Tired; Let Down
7 - Completely Exhausted; Unable to Function Effectively; Ready to Drop

Most parameters including altitude, indicated air-speed, heading, pitch, roll, and spoiler, flap and landing gear position are sampled once each second. The data are recorded in the English system of units or plain text messages. DFDR data are recorded sequentially on each of six tracks of a 1/4 inch mylar tape. A continuous stream of data for the most recent 25 hours of flight exists before previously recorded data is overwritten.

A DFDR copy recorder was used to make a high speed copy of these 25 hours of data immediately after each mission. The copy process required about 16 minutes. These end mission tapes were mailed to the Warner Robins Air Logistics Center where the digital data was transferred to 1/2 inch magnetic media compatible with retrieval and storage capabilities existing at the Armstrong Laboratory.

The Systems Research Laboratory Incorporated provided technical assistance and programmer expertise to assist with retrieving and analyzing the 25 hours of flight data on each mission tape. Routines to identify ILS landing segments were developed to search for flight parameters unique to an approach to landing. Heading and altitude from the inflight data checklist and flight information publications were usually adequate to identify the approaches of interest. The point of touchdown was confirmed by visual inspection of changes in airspeed, vertical velocity, thrust reverser settings, engine thrust, and pitch angle. Once touchdown was identified, the final 1500 feet of each approach was reviewed. Analyzing the tapes was difficult at times because DFDR data lacks reference markers to an external clock or mission identifier.

The data plots suggested that most approaches were stable by 1200 feet agl and that many pilots transitioned to visual cues 5-10 seconds before reaching decision height. Transition to visual cues could often be detected by changes in vertical velocity, heading, airspeed, pitch or other trend information indicating a final adjustment in aim-point and airspeed. To avoid including the visual transition in the data stream for the ILS, 10 seconds were subtracted from the reference time identifying 200 feet agl or decision height. From

this end point the preceding 80 seconds of each approach parameter (airspeed, heading, altitude etc.) were averaged and the standard deviations were calculated. Vertical velocity was an indirect measure calculated from the altitude readouts.

Two flight segments had less than 80 seconds of useable data because of a late turn to the final approach course and a late configuration change. On these flights, data near 200 feet agl was accepted. This adjustment provided almost 80 seconds of stable flight free of turns or configuration changes so that all 78 ILS approaches included nearly equal periods of observed data. No evidence of early transition to visual flight was evident for these two approaches.

For purposes of this study, it was assumed that the 80 second average represented the "target" value for airspeed, altitude, heading, roll and pitch. In this field setting, many factors could bias whether the data represented briefed target or ideal flight parameters. We reasoned that averaging each variable would remove bias caused by calibration errors, technique, compensation for winds and other external or environmental factors.

The standard deviation about the mean was used as a measure of how precisely airspeed, vertical velocity, heading, pitch and roll for an 80 second segment of the approach were controlled. These standard deviations were correlated with subjective fatigue ratings, POMS fatigue, oral temperature, recent 24- and 48-hour sleep history, length of duty day, cumulative 30-day flight hours, and location. The fatigue rating or other score within four hours after landing was preferred for these comparisons. If no value was recorded after landing an activity log entry within four hours before landing was accepted.

3 RESULTS

DFDR tapes were downloaded for 98 missions. Two DFDR recordings (3 approaches) were technically flawed and could not be analyzed. The remaining 96 recordings included 138 approaches and landings where flight deck observers

TABLE 2: Pearson Correlation and Probability of Some Fatigue Measures Associated with Landing

Correlation (r)▲ Probability Pr(r=0)▼	Subj Fatigue	POMS Score	Oral Temp	24 Hr Sleep	48 Hr Sleep	Length Duty D	30 Day Flt Hrs
Subjective Fatigue Rating	1.000	0.3673▲ 0.0013*▼	-0.1119 0.3293	-0.3069 0.0063*	-0.0866 0.4507	0.4050 0.0002*	0.1709 0.1372
POMS Fatigue Rating (Adjusted)	0.3673 0.0013*	1.000	-0.0519 0.6603	-0.2013 0.0855	-0.2522 0.0302*	0.3446 0.0026*	-0.0200 0.8667
Oral Temperature (at Landing)	-0.1119 0.3293	-0.0519 0.6603	1.000	0.0544 0.6359	0.2464 0.0297*	-0.1446 0.2066	-0.0769 0.5064
24 Hour Sleep History	-0.3069 0.0063*	-0.2013 0.0855	0.0544 0.6359	1.000	0.4370 0.0001*	-0.2552 0.0241*	0.0419 0.7173
48 Hour Sleep History	-0.0866 0.4507	-0.2522 0.0302*	0.2464 0.0297*	0.4370 0.0001*	1.000	-0.3328 0.0029*	0.0302 0.7945
Length of Duty Day	0.4050 0.0002*	0.3446 0.0026*	-0.1446 0.2066	-0.2552 0.0241*	-0.3328 0.0029*	1.000	0.3403 0.0025*
30 Day Flight Hours	0.1709 0.1372	0.0200 0.8667	-0.0769 0.5064	0.0419 0.7173	0.0302 0.7945	0.3403 0.0025*	1.000

* Significant (P < .05).

completed an inflight data sheet and/or cockpit voice recording. Eighty-three of these approaches used ILS course and glidepath guidance. Fifty-five of the 138 approaches were non-precision or other precision approaches, mostly flown because an ILS approach was not available at the destination. Data from 5 of the 83 approaches could not be interpreted for various technical reasons (DFDR copy recorder malfunctions, missing or poor data quality, or inability to identify the approach of interest on the data tape).

A correlation analysis of the measures used to estimate fatigue, i.e. subjective fatigue rating, POMS fatigue score, oral temperature, recent 24- and 48-hour sleep history, length of duty day and cumulative 30-day flight hours is included in Table 2. Cross validity was good although some expected associations such as between subjective fatigue and 48-hour sleep history were not found.

A pertinent finding from Table 2 related to the defined objective of the study was that 30-day flight history was not statistically associated with any of the fatigue measures except for an unclear relationship with length of duty day.

Interestingly, oral temperature at landing was not associated with POMS or subjective fatigue ratings (r = -0.1119; p = 0.3293). Temperature plots continue to be examined and do show the expected circadian rhythmicity and association with high subjective fatigue scores (r=-0.2108; p=.0001)(3). Of course, landings occurred at any time during the circadian cycle and very few occurred at the circadian trough in temperature.

Digital flight data did not detect any statistically significant deterioration of flying precision as fatigue ratings increased. However, isolated deviations in flying precision were noted.

TABLE 3: Airspeed Control Versus Fatigue

Airspeed vs Mean Standard Deviation	Mean Subj Fatigue	Mean POMS	Mean Oral Temp@Land
KIAS < .5 S.D. (n = 16)	3.88	47.8	36.7
KIAS >.5 ≤ 1 S.D. (n = 34)	3.97	47.2	36.6
KIAS >1 ≤ 1.5 S.D. (n = 14)	3.93	45.0	36.7
KIAS > 1.5 S.D. (n = 14)	4.43	54.7	36.6

Notes: KIAS is the standard deviation for airspeed for individual flight segments. Higher numbers indicate greater fatigue. Oral temps are in degrees Centigrade.

Flight Parameters

The following subheadings discuss each flight parameter studied and its relationship to the fatigue measures used.

AIRSPEED. Precision of airspeed control was not significantly related to subjective fatigue ratings, POMS fatigue, oral temperature, recent 24- and 48-hour sleep history, cumulative 30 day flight hours, crew position or time of day. Figures 1a and 1b demonstrate how airspeed control varied for a very precise and a less precise approach. The plots were selected to contrast pilots with similarly high fatigue ratings, sleep histories, and high cumulative flight hours. These approaches were both flown into the familiar home station airfield following a 10-14 day trips.

Of the flight parameters reviewed, indicated airspeed appears to be the most sensitive measure of pilot performance.

Although control of airspeed was not statistically associated with fatigue, inspection of individual plots suggested that fatigue may affect airspeed control in some cases but not in others. Table 3 suggests that the least precise approaches had

higher fatigue levels on the average than the most precise approaches. Least precise control in Table 3 is identified as an approach where the standard deviation of airspeed over the 80 second segment analyzed was greater than 1.5 standard deviations from the mean standard deviation for airspeed from all 78 approaches.

It is of interest that control of airspeed, vertical velocity, and pitch were significantly less precise for the six recorded ILS approaches into Frankfurt, Germany. Historically, aircrew complain about the difficulty associated with flying approaches into this very busy international airport where controller requests to help sequence arriving and departing traffic can distract a pilot from following standard procedures for an ILS.

HEADING. Heading control was not significantly related to subjective fatigue ratings, POMS fatigue, oral temperature, recent 24- and 48-hour sleep history, cumulative 30 day flight hours, crew position, time of day, or landing destination. Figures 2a and 2b demonstrate how heading varied for a very precise and a less precise approach. The plots were again selected to contrast individuals with similarly high fatigue ratings, sleep histories, and high cumulative flight hours. The approaches depicted were both flown to the same recovery runway in the continental United States following completion of a long transoceanic flight terminating a Desert Storm trip.
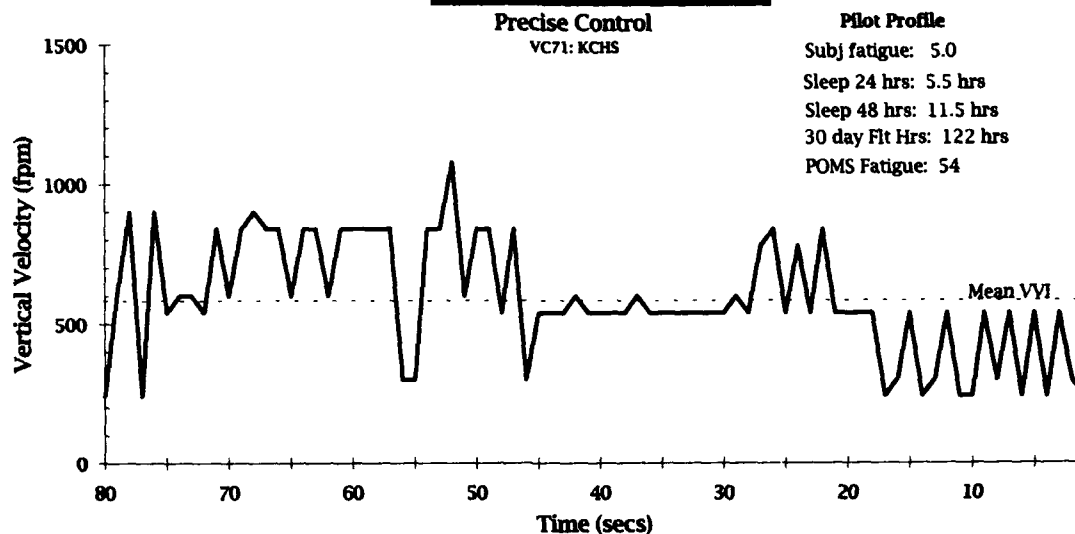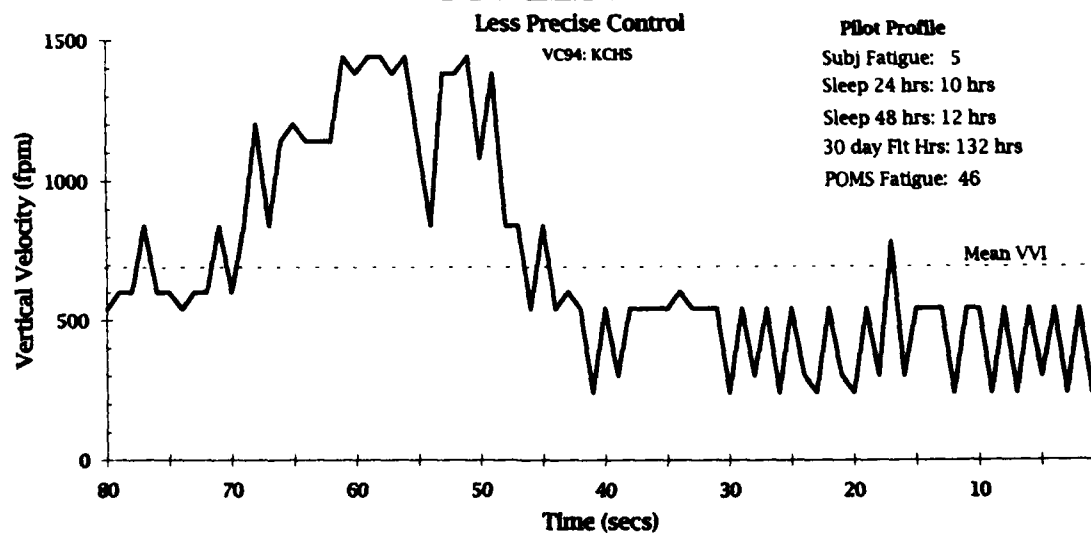
VERTICAL VELOCITY. Rate of descent was not significantly related to subjective fatigue ratings, POMS fatigue, oral temperature, recent 24- and 48-hour sleep history, cumulative 30 day flight hours, crew position or time of day. Figures 3a and 3b demonstrate how vertical velocity varied for a very precise and a less precise approach. The plots were again selected to contrast individuals with similarly high fatigue ratings, sleep histories, and high cumulative flight hours and were flown into the familiar home station.

PITCH. Pitch was not significantly related to subjective fatigue ratings, POMS fatigue, oral temperature, recent 24- and 48- hour sleep history,

Figure 1a: Indicated Airspeed

Precise Control
VC73: KCHS

Pilot Profile

Subj Fatigue: 4.0
Sleep 24hrs: 4.0 hrs
Sleep 48hrs: 20.5 hrs
30 day Fly Hrs: 144 hrs
POMS Fatigue: 52
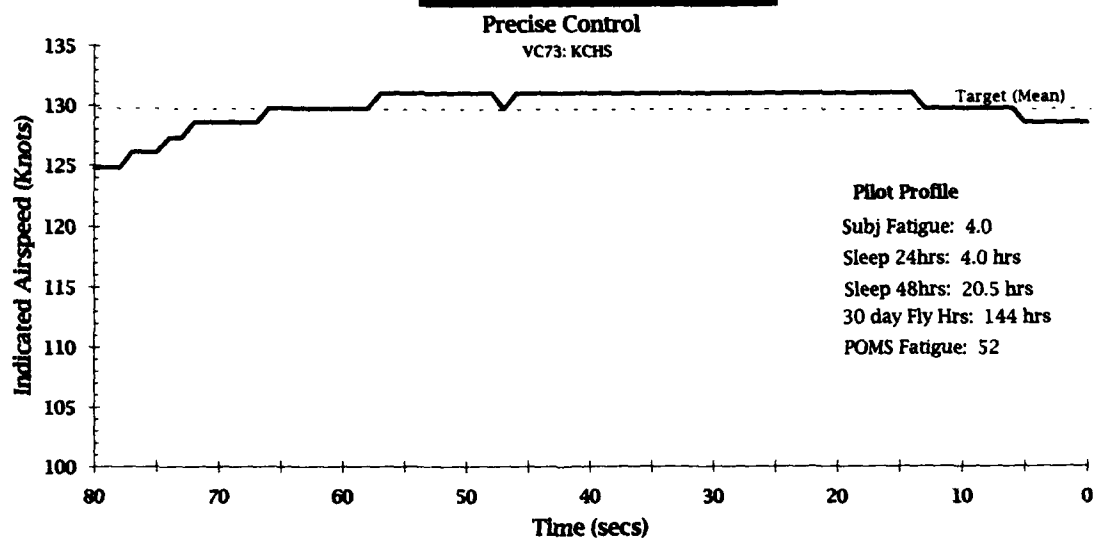
Figure 1b: Indicated Airspeed

Less Precise Control
VC34: KCHS

Pilot Profile

Subj Fatigue: 5.0
Sleep 24hrs: 8.0 hrs
Sleep 48hrs: 8.0 hrs
30 Day Flt Hrs: 121 hrs
POMS Fatigue: 57
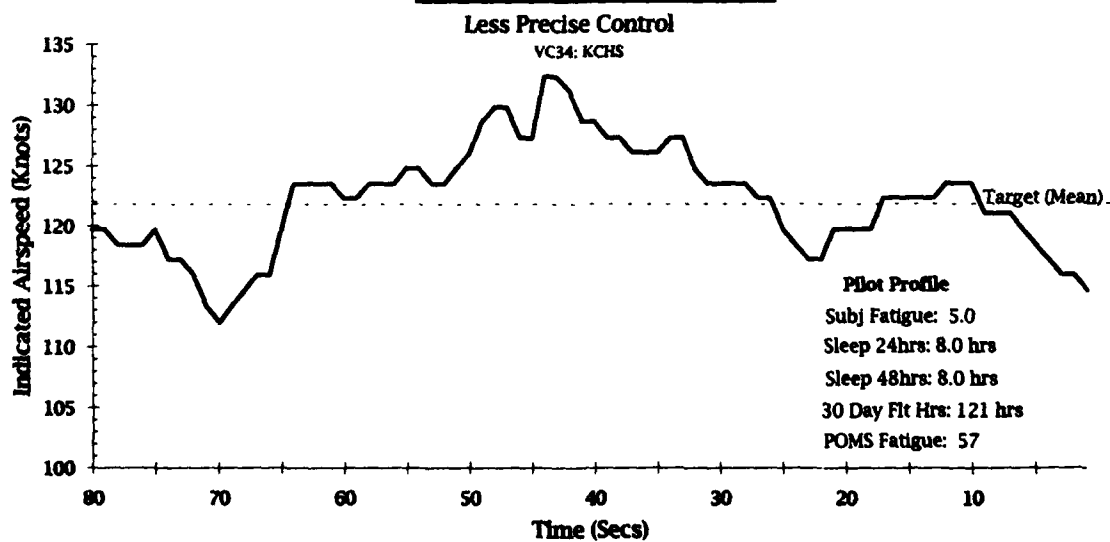
Figure 1: Plot of Indicated Airspeed for a Precise and Less Precise Approach

Figure 2a: Heading

Precise Control
VC97: KWRI

Mean Heading

Pilot Profile
Subj Fatigue: 6.0
Sleep 24hrs: 5.5 hrs
Sleep 48hrs: 9.5 hrs
30 day Flt Hrs: 146 hrs
POMS Fatigue: 55

Heading (degrees) — Time (secs)

Figure 2b: Heading

Less Precise Control
VC74: KWRI

Mean Heading

Pilot Profile
Subj Fatigue: 5.0
Sleep 24hrs: 7.0 hrs
Sleep 48hrs: 15.5 hrs
30 day Flt Hrs: 142 hrs
POMS Fatigue: 69

Heading (degrees) — Time (secs)
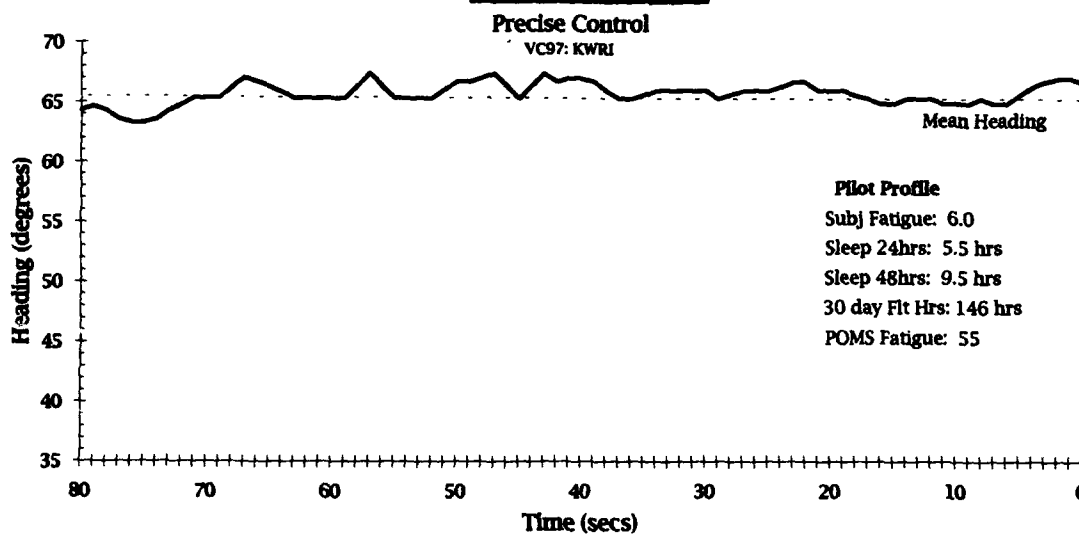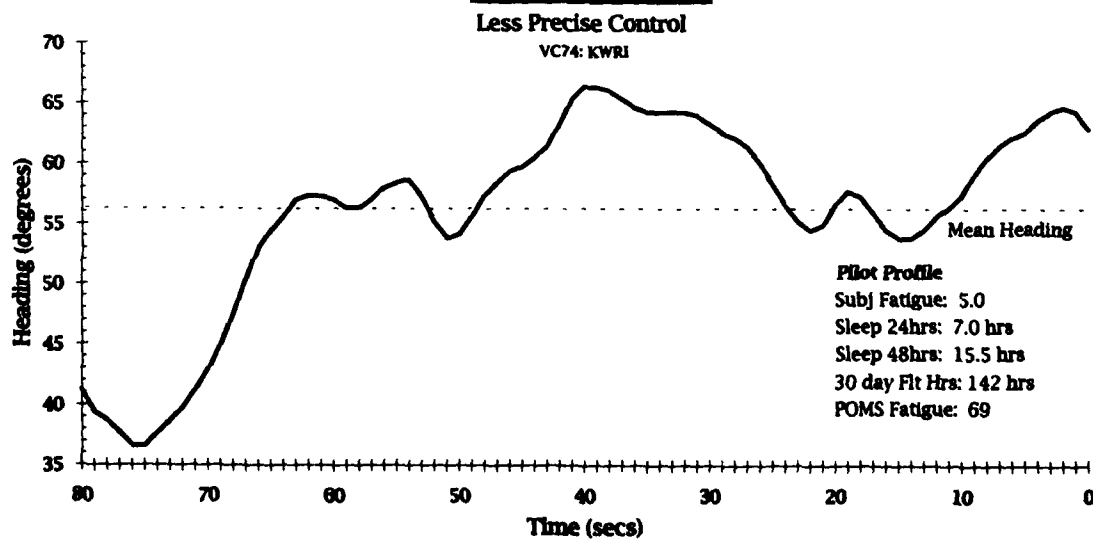
Figure 2: Plot of Heading for a Precise and Less Precise Approach

Figure 3a: Vertical Velocity

Precise Control
VC71: KCHS

Pilot Profile
Subj fatigue: 5.0
Sleep 24 hrs: 5.5 hrs
Sleep 48 hrs: 11.5 hrs
30 day Flt Hrs: 122 hrs
POMS Fatigue: 54

Figure 3b: Vertical Velocity

Less Precise Control
VC94: KCHS

Pilot Profile
Subj Fatigue: 5
Sleep 24 hrs: 10 hrs
Sleep 48 hrs: 12 hrs
30 day Flt Hrs: 132 hrs
POMS Fatigue: 46

Figure 3: Plot of Vertical Velocity for a Precise and Less Precise Approach

cumulative 30-day flight hours, crew position or time of day.

ROLL. Roll was not significantly related to subjective fatigue ratings, POMS fatigue, oral temperature, recent 24- and 48-hour sleep history, cumulative 30 day flight hours, crew position, time of day, and landing destination.

Data plots of aircraft pitch and roll are very similar to those for depicted vertical velocity, heading and airspeed.

4 DISCUSSION

The rich atmosphere of the actual flight environment where motivation, technique, cockpit resource management, and other factors interact in complex ways is the laboratory where all flight related research must eventually be validated. Subjective reports of fatigue are not always accompanied by performance decrements. Decreased performance on psychomotor and cognitive tasks do not always mean lower performance will be observed on dissimilar tasks (like operating an aircraft). Digital flight data offers a way to obtain meaningful, sensitive measures of actual pilot performance in the cockpit laboratory where aircrew live and work.

This rich environment is very difficult to control. The study was limited by inability to control for the effects of wind, and other environmental conditions that can affect pilot performance. Although the pilots were briefed on the study requirements, they did not always attempt to fly with the level of precision desired for flight test research. As noted, pilot techniques, calibration, and other factors made using briefed or "target" values for airspeed, altitude, and heading control problematical. Compliance with procedures was good but it is not certain whether all ILS approaches were flown fully uncoupled from approach aids or using the same set up of instrument approach aids. Additionally, other crewmembers freely assisted with approach duties. Sharing approach duties may have helped tired pilots recruit physiological reserves to compensate for impaired performance.

Since this was a first attempt at acquiring these types of data, it was not possible to anticipate defining some of the factors that increased experience might have permitted us to control. Most of these limitations can be overcome, but Desert Storm presented special challenges along with a very unique opportunity for acquiring these data.

We did not find that 30-day flight hours were strongly associated with any of the fatigue measures taken immediately after or before landing except for length of duty day. It may be that high 30-day flight hours introduced an element of chronic fatigue that lowered reserves for extended duty days, but other explanations are possible.

The 30-day limit on flying hours may appear to work in practice because maintenance limitations, crew rest requirements and other logistical and technology factors have made exceeding these limits very unusual. Aircraft reliability, mission durations, and mission frequency during Desert Shield and Desert Storm made the potential to approach and exceed these limits a relatively common event. Based upon cross validation with other fatigue measures (Table 2), we conclude that 30-day flight hours are not a very sensitive measure of cumulative or chronic fatigue.

Boll et. al. address fatigue ratings and recovery with these same data and conclude that the present 30-day flying duty restrictions are safe and should be retained(2). This is an appropriate recommendation, but it should be extended. When crews are expected to reach or exceed these 30-day limits, measures of subjective fatigue, moods surveys, recent sleep history, circadian dysrhythmia, and length of duty day should be considered by schedulers at the stage. Consideration of these factors can assist with decisions to extend crew rest or to restrict duty day when indicated. These assessments can also be used to extend capabilities. The unifying concept in applying these lessons learned is the development of a fatigue management system.

Individual examples of lower performance associated with high fatigue ratings and indicated airspeed, heading, vertical velocity, pitch and roll are easy to find. Nearly as many examples can be

found where high fatigue ratings were accompanied by excellent performance. Fatigue is insidious. In most cases pilots can compensate for fatigue by any number of strategies to recruit physiological reserves to increase alertness, attention and situational awareness. Some of these strategies are more effective than others. It will be a challenge to integrate fatigue management strategies into training programs for flight surgeons, operational planners and aircrew. Enough is known about fatigue management that aircrew should not have to rely on anecdotes, trial and error, aircrew complaints, or other less effective strategies.

Use of digital flight data is almost exclusively limited to aircraft accident investigation. When the "black box" survives a fiery crash, it nearly always contains the key performance data needed to document and explain the mishap sequence. In an intact aircraft, the recorder is much more reliably accessed and can provide equally critical performance data. In controlled studies, the DFDR offers a means of assessing any number of performance and situational awareness issues. It could be used to validate or augment expensive flight test studies of workload, performance, and cockpit displays. Digital flight performance offers a convenient method to objectively evaluate the final approval of candidate drugs for use in aircrew.

Another obvious application for existing digital flight data recorders is to link the data output to a computer for real time analysis of deviations from expected control parameters. Computerized trend analysis is a big step over the logic of present devices that command "too low - pull up" or "too slow - stall" to warn aircrew that they have gone below minimums. Detection of adverse trends would serve as an early warning to pilots when vigilance, attention deficits or situational awareness has deteriorated to alarming levels. Once warned, various recruitment strategies can be employed to avoid further problems.

The DFDR could also augment flight history recorders for real time or post flight analysis of engine performance and other maintenance-related trend information.

Flight surgeons brief aircrews prior to deployments, but do not have a well defined roll in stage management or operational planning for fatigue management. They receive some training on circadian dysrhythmia and fatigue but applied principles to assist operations planners are limited. Training programs to give flight surgeons the tools they need to perform their consultant role in managing fatigue need to be developed.

Planners never fully anticipated triple turning F-15s and A-10s or routine combat air patrol missions of six hours or more. Present guidelines work, but new political realities call for planning unaugmented missions with crew duty days of 30-36 hours. Specific recommendations for nutritional support, phase shifting circadian rhythms, enhancing crew rest, encouraging proper inflight rest schedules, and optimizing post mission recovery need to be codified. Probably the most important step is to include fatigue management, sleep hygiene, approaches to shift work, recruitment strategies, drug enhancement of sleep and performance and nutritional education in crew resource management and other training programs. Good fatigue management can facilitate acquiring greater than 150 hours in 30 days when mission requirements dictate. It may also help avoid imbalances caused when 125 or 150 hours are acquired in less than 30 days and aircrew have not had adequate time for restorative rest and recovery.

Recent efforts to downsize the military, improved aircraft reliability and maintenance, and improved logistical capacities increase the threat of fatigue becoming a limiting human factor. In the future there will be fewer forward operating locations where access for staging military operations can be assured. The deployment and redeployment experience and requirements to support the global projection of power envisioned by leaders in the United States Air Force heighten the need for including fatigue management in operational planning. The lessons of Desert Storm and Desert Shield contained in these operational studies point the way to establishing a road map for fatigue management.

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Effects of Caffeine on Mental Performance and Mood: Implications for Aircrew Members

Harris R. Lieberman, Bernard J. Fine, John L. Kobrick
and John D.E. Gabrieli[1]

Military Performance and Neuroscience Division
Occupational Health and Performance Directorate
U. S. Army Research Institute of Environmental Medicine
Natick, MA. 01760, U.S A.

Department of Psychology[1],
Stanford University, Stanford, CA 94305, U.S.A.

1. SUMMARY

Caffeine is generally regarded as the most widely used drug in the world. However, it is also a food constituent. Its acute effects on behavior appear to be greater than those of any other food constituent as they are detectable when caffeine is administered in doses found in single servings of coffee, tea and soft drinks. Caffeine affects the central nervous system by binding to adenosine receptors, and it has acute and chronic, dose dependent, effects on brain function. Low and moderate doses have beneficial effects on mental performance but high doses may have adverse effects. Tolerance develops to continued use of caffeine, so that its acute effects are altered when it is used chronically in high doses. Physical and mental symptoms associated with sudden withdrawal of caffeine have also been reported. The acute effects of caffeine on vigilance, simple and complex cognitive performance, and mood state are discussed. Doses equal to single servings of beverages consistently improve auditory and visual vigilance. In addition, moderate doses of caffeine increase self-reported alertness. The duration and magnitude of these effects on individuals are related to habitual caffeine consumption and interact with tobacco use. In view of its dose-related beneficial and deleterious effects, aircrew personnel, flight surgeons, military commanders and planners should have knowledge of the potential influence of caffeine on performance, especially vigilance, and mood, as well as the consequences of its abrupt withdrawal.

2. INTRODUCTION

A variety of food constituents have been studied to determine their potential influence on behavior. Tryptophan, tyrosine, phenylalanine, choline, caffeine, protein and carbohydrate have been administered to both humans and laboratory animals and their effects on a variety of behaviors evaluated (for a recent review see Lieberman, (1)). With the exception of caffeine, the literature on each substance is quite limited. Even so, it is apparent that when the magnitude of the behavioral effects

of food constituents are compared, caffeine is the most potent. When the effects of caffeine are contrasted to those of other food constituents on an equal weight-to-weight basis (i.e., 100 mg of caffeine versus 100 mg of any other food constituent) the magnitude of caffeine's effects appear greater. Furthermore, caffeine appears to have an even greater advantage when the comparison is based on the effects produced by single servings of common foods (1). The choline, tryptophan or carbohydrate, etc. that is found in a single serving of any food will not have effects that are as large or consistent as the those produced by the caffeine in a typical beverage (1). In fact, based on the currently available literature it appears that caffeine is the only food constituent that has been shown to unequivocally affect behavior when it is administered in the doses found in common foods (2). Of course, future studies may demonstrate that other foods have unexpected or greater effects on behavior.

3. CAFFEINE IN THE DIET

Caffeine (1,3,7-trimethylxanthine), theobromine (3,7-dimethylxanthine) and theophylline (1,3-dimethylxanthine) are naturally-occurring substances found in foods and drugs (Fig. 1). Of the three, caffeine is the most important since it is consumed in much larger quantities than the other two (2,3). In addition to being the xanthine found in coffee, caffeine, not theophylline, is the primary xanthine found in tea. In spite of reports in the popular press to the contrary, caffeine is much more abundant in tea than any other xanthine. By weight, tea leaves are reported to contain about 3.2 percent caffeine but only 0.03 percent theophylline. Trace amounts of theophylline are also found in coffee and cocoa. Theobromine is found in significant quantities in cocoa but it is not believed to be behaviorally active in the doses found in foods (4,5). Cola beverages also contain significant amounts of caffeine but most is added, although kola nuts, which are used to flavor colas, contain some naturally-occurring caffeine (2,5).
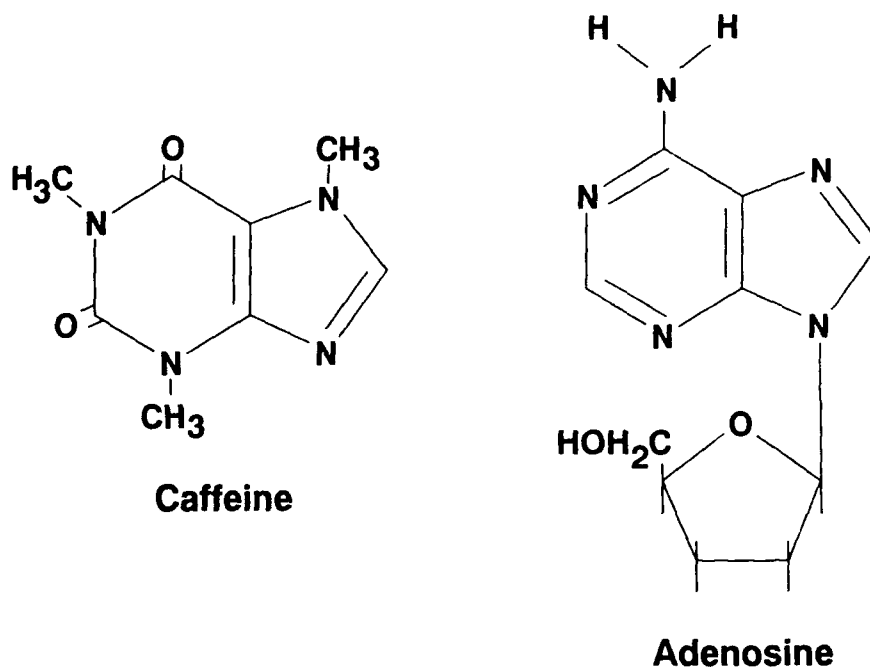
Figure 1. The structural formulae of the three methylxanthines found in foods and drugs (2).

Although there are considerable differences among the NATO countries in patterns of beverage consumption, there is good evidence that total caffeine intake is similar across nations. Coffee consumption is highest in the Scandinavian countries, followed by Germany, Canada and the U.S. and lowest in the United Kingdom and the Mediterranean countries (6). However, higher consumption of tea in the United Kingdom may substitute for lower consumption of coffee. In Canada about 60% of caffeine intake is from coffee and 30% from tea (6). Coffee is also the predominant source of dietary caffeine intake in the United States, with about 70% derived from this source and 15% from tea (5-7). It has been estimated that in Western Europe total daily caffeine intake is about 245 mg/day (6). Total per capita caffeine intake in the United States is approximately 195 mg/day (2,5,7,8).

In order to evaluate the effects that caffeine consumption may have on aircrew members it is essential to have accurate information on intake and temporal patterns of caffeine consumption. Unfortunately, gathering such information is a more difficult undertaking than might be supposed. Although there is considerable variation in the macronutrient composition of specific foods, it is generally possible, based on dietary records, to estimate the proportion of protein, carbohydrate and fat and arrive at reasonably reliable intake estimates. However, because caffeine and related compounds occur naturally in coffee,

tea and chocolate, there is considerable variability in their concentration before preparation. Furthermore, the method of preparation greatly increases variability in the caffeine content of the actual food or beverage. A weakly brewed beverage will contain considerably less caffeine than a strong one. Preparation is especially critical for coffee. Coffee prepared using the drip method contains, on average, the most caffeine, about 110 mg/cup, while instant (soluble) contains considerably less, about 60 mg/cup on average (Table 1) (2,5,9). In addition, each type of coffee can vary tremendously with respect to actual caffeine content. Roasted and ground coffee may contain from 40-150 mg/cup, while instant coffee has from 40-108 mg/cup (3,8,10,11). Arabica varieties of coffee, usually classified as higher quality on the basis of taste, contain substantially less caffeine than the lower quality robusta beans (2). Tea, most cola beverages and other soft drinks, typically contain less caffeine per serving than coffee. One cup of tea, as it is brewed in the United States, contains about 40 mg of caffeine and most colas 30-40 mg per 12 oz. serving (Table 1) (2).

Caffeine also is found in certain over-the-counter (OTC) and prescription medications. For example, the recommended dose of one North American OTC pain medication contains 64 mg of caffeine in addition to aspirin. A variety of OTC preparations, in which caffeine is the only active ingredient, are available in the United

TABLE 1

CAFFEINE CONTENT OF SELECTED BEVERAGES AND FOODS*

Item	Caffeine Content (mg)
Coffee (5-oz cup)	
Drip method	90-150
Percolated	64-124
Instant	40-108
Decaffeinated	2-5
Instant decaffeinated	2
Tea, loose or bags (5-oz cup)	
1-min brew	9-33
3-min brew	20-46
5-min brew	20-50
Tea products	
Instant (5-oz cup)	12-28
Iced tea (12-oz can)	22-36
Chocolate products	
Hot cocoa (6 oz)	2-8
Dry cocoa (1 oz)	6
Milk chocolate (1 oz)	1-15
Baking chocolate (1 oz)	35
Sweet dark chocolate (1 oz)	5-35
Chocolate milk (8 oz)	2-7
Chocolate-flavored syrup (2 tbsp)	4
Cola Beverages (12-oz)	
Coca-Cola Classic	46
Pepsi	38
Coke	46
RC Cola	36
Diet Pepsi	36
Diet Coke	46
Diet RC Cola	48
TAB	46
Other Soft Drinks	
Dr. Pepper	41
Diet Dr. Pepper	41
Mountain Dew	54
Mellow Yellow	52
Diet Mellow Yellow	12
Mr. Pibb	40

* Lieberman (2).

States for use as stimulants. A dose of 100-200 mg is recommended by the manufacturers. Theophylline, often in high doses, is used to treat asthma. However, drugs probably account for only a small part of the total xanthine intake in the United States because so much of these compounds are consumed in foods. Flight surgeons, other medical personnel and individuals themselves need to be aware of these sources of caffeine, since the effects of such drugs will be additive with respect to dietary caffeine intake and, if consumed on a regular basis, they will produce tolerance to the effects of caffeine. Given the unusually large variation in caffeine content in common foods, particularly coffee and tea, it is probably quite difficult to arrive at accurate quantitative caffeine intake estimates for individuals by using dietary records alone. However, it is not difficult to accurately classify individuals as low, moderate or high users of caffeine based on careful recording of daily consumption of caffeine-containing foods. When such estimates are compared to the individuals' plasma caffeine concentration there is reasonable agreement between the subjective and objective methods (Lieberman, unpublished observations). When estimates of caffeine intake for aircrew members are based on dietary surveys, it is important to consider duty

versus off-duty periods since caffeine consumption varies with the work-rest cycle (12). There appear to be little data in the literature concerning the use of caffeine by aircrew members. However Graeber (12), has documented high levels of caffeine use by commercial pilots when they are fatigued.

4. CAFFEINE'S MECHANISM OF ACTION

Caffeine, when it is administered in the levels found in the diet, appears to act by blocking the effects of adenosine (13). Adenosine is a neuromodulator that is found throughout the brain and periphery. Several classes of receptors with selective affinity for it have been identified, including the A_1 and A_2 subtypes (14). Adenosine has been found to have potent inhibitory actions and the methylxanthines appear to act by inhibiting the binding of endogenously released adenosine at its receptor sites (2,5). Central nervous system activity increases when the inhibitory action of adenosine is blocked. Several other mechanisms of action, such as phosphodiesterase inhibition, have previously been proposed to explain the behavioral effects of caffeine. However, caffeine appears to exert its effects on adenosine receptors at much lower concentrations than that needed to affect any other in vivo mechanism.

5. FACTORS AFFECTING INDIVIDUAL SENSITIVITY TO CAFFEINE

A variety of factors will modify the responsiveness of an individual to caffeine. In general the plasma half life of caffeine is 5-6 hours, with peak levels achieved from 15 to 45 minutes after ingestion (15,16). However, among cigarette smokers caffeine's half-life is only 3-4 hours (16). Oral contraceptive use appears to increase caffeine half life to approximately 11 hours and, in pregnant women, caffeine's half-life increases to 18 hours. In addition, there are data to suggest that are genetic differences in sensitivity to caffeine, although this has not been firmly established (17). Another critical factor determining an individual's sensitivity to caffeine is baseline level of caffeine consumption because tolerance develops when the substance is consumed on a regular basis (18). These individual differences, as well as the uncontrolled use of caffeine immediately prior to testing, must be considered when studies of caffeine are conducted. Furthermore, when recommendations concerning caffeine use are made to aircrew and ground personnel such individual factors must be carefully weighed.

6. EFFECTS OF CAFFEINE ON BEHAVIOR

Although there have been more studies on the behavioral effects of caffeine than on any other food constituent, there exists only a very limited description of caffeine's effects on behavior. Comprehensive studies of caffeine's effects on human behavior have not been conducted, even though this substance is consumed on a daily basis in behaviorally active doses by hundreds of millions of people. Although we lack a comprehensive view of caffeine's effects on behavior, there is good evidence that its consumption, in the doses found in single servings of foods, significantly affects certain key aspects of performance and mood state. Until recently even this simple conclusion was not generally agreed upon by a consensus of scientists (2).

6.1 Vigilance

Although several papers appeared in the 70's indicating that caffeine in moderate doses would increase vigilance (19,20), later investigators were not always able to replicate these findings (21). The reasons for this inconsistency have been discussed in detail elsewhere and seem to be attributable to both the nature of the tasks employed to assess vigilance and differences in experimental design (1,2).

In an effort to reliably document the effects of caffeine on the behavior of normal individuals, including military personnel, my colleagues and I have developed several standardized testing paradigms that have consistently detected effects of caffeine on vigilance. In an initial study, we compared several vigilance tests and found that one in particular, the Wilkinson vigilance test (22), was sensitive to a wide range of caffeine doses (23). The Wilkinson test assesses sustained auditory vigilance and was initially developed to detect the effects of sleep deprivation on performance (22). The test is typically conducted for one hour without interruption. During the test period a 400 millisecond tone is presented once every two seconds. However, forty of the tones are approximately 70 milliseconds shorter than the rest and the subject must correctly identify these infrequent signal tones by responding on a computer keyboard. Task difficulty is equated from subject to subject by slightly varying the duration of the test stimuli. The original version of the test does not vary test duration across subjects (23).

Twenty males participated in our initial double-blind, crossover study. Caffeine consumption was restricted for 12 hours before each test day and smokers and individuals who normally consumed more than 400 mg of caffeine per day were excluded. Caffeine was administered in capsule form at 0800 h in doses of 32, 64, 128 and 256 mg and subjects were tested until 1100 h. Vigilance, as assessed by total number of correct detections on the Wilkinson task, was significantly improved by all four doses of caffeine. Error rate was not altered by caffeine administration (Fig. 2) (23). Effects were observed when only 32 mg of caffeine were administered, a dose not typically considered to be behaviorally active. In subsequent studies we have consistently documented effects of caffeine with the modified Wilkinson task. In one study we found that caffeine alone (64 mg) and caffeine (64 and 128 mg) in combination with aspirin, improved vigilance (24). In another study we replicated our original findings using 64 and 128 mg of caffeine (25). We have also observed similar effects of caffeine on women and elderly volunteers (Lieberman et al, unpublished observations), again using doses of 64, 128 and 256 mg.
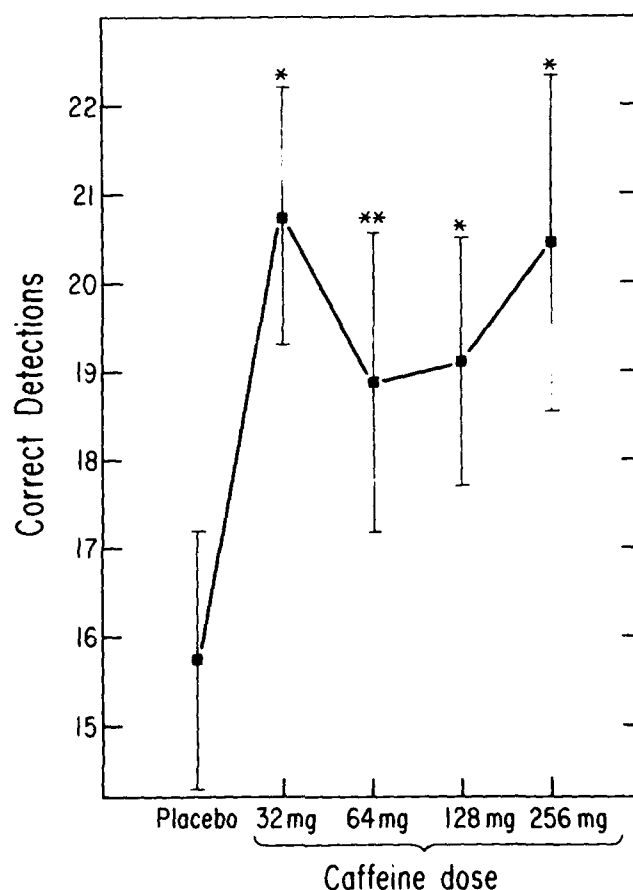
Effect of Caffeine on Auditory Vigilance

Figure 2. The effects of caffeine in doses of 32-256 mg and placebo on mean (±SEM) number of correct detections on the Wilkinson auditory vigilance task (* indicates p<.005 compared to placebo; ** indicates p<.01 compared to placebo on post hoc tests)(23).

In a study recently conducted with 24 soldiers, we demonstrated that the effects of caffeine on vigilance could be also be readily detected with a specially designed test of visual vigilance (26). The test developed was of extended duration (two hours) and, like the Wilkinson vigilance task, had a low rate of critical signal presentation. During the test a rectangular cursor was presented for two seconds on the 9" x 11" monochrome video screen of an IBM-compatible personal computer. During the two hour test period there were 120 stimulus presentations. The cursor appeared at various locations on the screen so the subject had to continuously scan for its appearance. When a stimulus was detected, subjects were instructed to respond by pressing the space bar of their computer's keyboard.

As in the modified version of the Wilkinson vigilance task, difficulty was individually adjusted for each subject by varying the brightness of the cursor.

The study was conducted using 200 mg of caffeine administered at 0800 h. A double-blind, crossover design was employed. Caffeine significantly facilitated performance as assessed by number of correct detections and response time. The effects of caffeine were observed throughout the two hour test session as illustrated by Fig. 3. Unlike several previous studies (23-25) smokers and individuals who consume high levels of caffeine were not excluded from participation in this study and they responded differently to caffeine than other subjects (26).
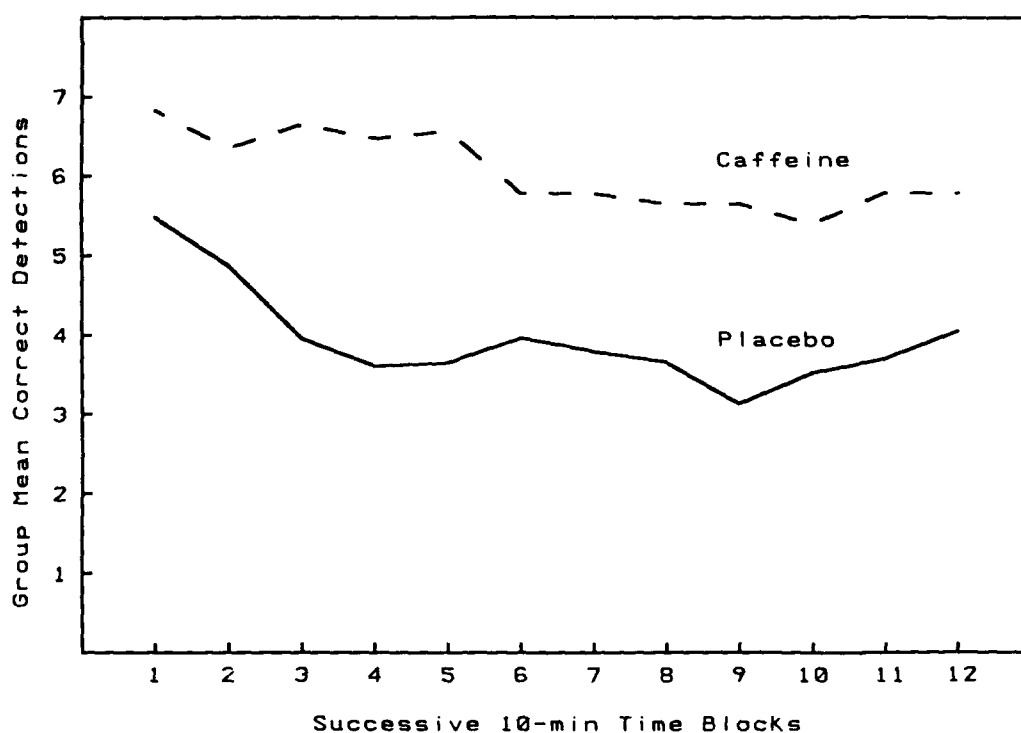
Figure 3. Mean number of correct detections in 10 minute time blocks for caffeine (200 mg) and placebo. The test employed assessed visual vigilance (26).

These studies demonstrate that caffeine can reliably increase vigilance when an appropriate task of the appropriate duration is employed in a well-controlled testing environment.

6.2 Psychomotor Performance and Cognition

Although vigilance appears to be the behavioral parameter most readily altered by caffeine consumption, there is evidence that certain other types of performance are also affected by caffeine consumption. Several studies have observed effects of caffeine on reaction time. When it is administered in low to moderate doses caffeine appears to facilitate responsiveness to stimuli (20,23,27,28), although not all investigators have reported such effects (29). In addition, at least one study found that high doses of caffeine, when administered to individuals who normally consume little caffeine, slowed responding (30). Another study reported that high doses of caffeine (600 mg) were not as effective as moderate doses (200 and 400 mg) at improving choice reaction time (28). In general, it seems likely that moderate doses of caffeine have positive, but difficult to detect, effects on simple and complex reaction time. Generalizations regarding the effects of caffeine on other aspects of performance are even more difficult to

reach. Complex cognitive functions, such as learning and memory do not appear to be sensitive to caffeine administration and little information is available on the effects of caffeine on sensory processing. For a recent review see Lieberman (2).

6.3 Simulator Studies

In spite of the widespread use of caffeine in the general population few studies have been conducted to determine whether caffeine may have beneficial or harmful effects in simulated or real work environments. In one study the effects of 200 mg of caffeine was tested on 24 young males in a laboratory simulation of long duration highway driving (19). In that study 200 mg of caffeine significantly improved several kinds of performance including response time to accelerations and decelerations of a lead car. The results of this study are similar to those investigating caffeine's effects on vigilance using laboratory tasks that reliably detect effects of caffeine.

In a study simulating a basic military task, sentry duty, Johnson (31) evaluated the effects of 200 mg of caffeine. Using a specially modified Weaponeer Rifle Marksmanship Simulator, which employs a modified M16A1 rifle,

performance was assessed for three hours after administration of caffeine or placebo. The soldiers participating in the study were required to respond to the infrequent appearance of a target by picking up a rifle and aiming and firing as rapidly, and accurately, as possible. Caffeine decreased detection time but did not significantly increase the total number of targets that were hit.

These studies would appear to have important practical implications for certain aviation related occupations. It is likely that when vigilance must be maintained for long periods of time, caffeine use may, in certain circumstances, be a critical factor. Furthermore, these postulated beneficial effects may increase in situations where vigilance is reduced due to jet lag, sleep loss, or circadian variations in arousal (2). Future studies, to extend these findings, should be conducted in a variety of aviation-related simulators, and when practical, in actual work environments. In addition, when certain accident investigations are conducted, it may be appropriate to determine if there have been changes in the normal patterns of caffeine use by the personnel involved.

6.4 Effects of Caffeine on Mood State
While the effects of caffeine on many types of cognitive performance remain unresolved, there is little doubt that moderate doses of caffeine can significantly affect a variety of mood states. As would be expected from the effect that caffeine has on vigilance, its effects on mood appear greatest on those factors associated with alertness. For example, a number of studies have reported significant effects of caffeine, in doses of 64-200 mg, on the Vigor and Fatigue sub-scales of the Profile of Mood States (POMS) (24-26). The POMS is a self-report mood questionnaire often employed in psychopharmacologic studies (32). Other investigators have observed significant positive effects of caffeine on alertness, well-being, concentration, and a number of related states, when administered in a dose of 100 mg (28). In another study, increased alertness, vigor and decreased fatigue were observed when caffeine was administered in doses of 200, 400 and 600 mg (33). Some of the effects of caffeine on mood may be biphasic, depending on dose. Many individuals believe that caffeine increases anxiety, and at high doses, above 300 mg, this may be true, especially among individuals who do not normally consume large amounts of caffeine (34,35). However, at lower doses of 64-128 mg, which are more typical of those found in single servings of foods, caffeine may decrease anxiety, at least under certain circumstances (2,25).

6.5 Adverse Behavioral Effects of Caffeine
It has been reported that consumption of more than 600 mg of caffeine per day may induce in normal individuals a syndrome known as "caffeinism", which is characterized by abnormally high levels of anxiety, poor sleep and somatic complaints similar to those seen among patients suffering from anxiety neuroses (36). In addition, caffeine has been linked, at least anecdotally, with impaired fine motor

performance. The scientific literature is contradictory on this issue. In a study discussed above, we found no evidence that doses of 32-256 mg of caffeine altered performance on complex motor tasks when low and moderate users were tested (23). However, Kuznicki and Turner (29) found that 160 mg, but not lower doses of caffeine, disrupted hand steadiness of individuals who did not usually consume caffeine, but had no adverse effects on regular caffeine consumers. As with other consequences of caffeine consumption, any adverse effects of caffeine on fine motor performance are dose-dependent and a function of the extent of habitual caffeine use by the individual.

Under certain circumstances caffeine appears to interfere with sleep, as would be expected from a compound that increases alertness. Adverse effects on sleep appear to be greatest when high doses of caffeine are consumed before bed by individuals who normally are not regular users of caffeine (2,37). However, many individuals report that they can consume coffee or other caffeine containing beverages before bedtime with no adverse effect (37,38).

The sudden withdrawal of caffeine from a diet that includes substantial amounts consumed on a regular basis, often appears to have adverse effects on the individual. Most notable is headache, which is relieved by consumption of caffeine. Caffeine-withdrawal headaches are also relieved by OTC analgesics and spontaneously remit after a few days of caffeine withdrawal (2,5). Such headaches may occur as the result of changes in vascular tone produced by hypersensitivity of adenosine receptors in the scalp and cranial blood vessels after caffeine withdrawal (39). Adverse effects of caffeine on mood-state, such as increased fatigue, have also been reported following its sudden withdrawal from the diet of heavy users (18).

The effects of caffeine withdrawal need to be carefully considered by flight surgeons and others since it may impair performance. Recommending the sudden withdrawal of caffeine from the diet could, at least theoretically, lead to serious adverse consequences with respect to job performance. It may be advisable for individuals who wish to reduce or eliminate caffeine from their diet to do so gradually (2). In addition, individuals who are heavy users of caffeine should be advised that its sudden withdrawal may produce a headache, adverse changes in mood-state and possibly impair performance.

It has been suggested that caffeine has addictive properties, and is similar in various respects to commonly abused substances (18). The evidence cited to support this association includes the adverse physical effects of caffeine withdrawal (for a review see Griffiths and Woodson, (40)), as well as certain animal and human behavioral research findings. This is a controversial area and although some scientists believe caffeine should be classified as a drug of abuse, others strongly disagree. For example, Hirsh (5)

states that caffeine has minimal abuse potential. In any case even scientists who believe caffeine can be abused concede that it has low abuse potential compared to more widely recognized drugs of abuse (40).

7. CONCLUSION

As discussed above, caffeine, when it is consumed in doses found in many foods, can improve the ability of individuals to perform tasks requiring sustained vigilance, including simulated automobile driving (2,19). Caffeine also improves the performance of soldiers engaged in a simulated marksmanship task that requires sustained vigilance for optimal performance (31). Sustained vigilance, particularly the ability to detect infrequent but critical stimuli, is essential for the optimal performance of many key aviation tasks, therefore it is likely that these beneficial effects will transfer to certain aviation related occupational duties.

Adverse behavioral effects of caffeine occur when it is consumed in excessive doses or by individuals who are overly sensitive to the substance (2). Higher than normal levels of anxiety may result and sleep may be affected. Since regular consumption of caffeine appears to produce tolerance to its behavioral effects, its sudden withdrawal from the diet may produce adverse symptoms such as headache and undesirable changes in mood state. The performance of individuals who are heavy consumers and have caffeine suddenly withdrawn from the diet may be impaired.

Unfortunately, the effects of caffeine on performance in actual or simulated flight operations or other aviation-related duties such as air traffic control have not been conducted. There is a critical need for such studies if rational recommendations are to be made to military planners, unit commanders, and flight surgeons regarding the use of caffeine by aircrew members.

Therefore, it is not possible to conclusively address the issues associated with the risks and benefits of caffeine use by aviation personnel. Positive behavioral consequences of caffeine consumption, such as increased ability to sustain vigilance and higher levels of self-reported alertness, are well documented. These beneficial effects clearly generalize to simulations of highway driving, sentry duty, and presumably similar aviation-related operations. It is possible that appropriate use of caffeine in such circumstances could prevent accidents attributable to lapses of vigilance (2). However, adverse effects of caffeine on sleep quality have been observed and some scientists believe that caffeine has many characteristics of an addictive drug. In addition, reports suggesting an association of caffeine consumption with the incidence of various diseases have appeared in the epidemiologic literature. However, at the current time no definitive data exist linking caffeine to any chronic disease and an expert panel has stated that "while questions about the ultimate safety of caffeine remain, there is solid evidence supporting the view that moderate amounts are not harmful to the average healthy adult" (11).

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14. Abstract

These proceedings include the Technical Evaluation Report and 30 papers of the symposium sponsored by the AGARD Aerospace Medical Panel and held at the Royal Christiania Hotel in Oslo, Norway from 19th—23rd October 1992. The theme of the symposium was to review and update the knowledge pertaining to diet and nutrition as it applied to aircrew. The metabolic disorders, including hyperlipidemia and alterations of carbohydrate metabolism, are common problems in aviation medicine that demand specific attention and management by NATO flight surgeons. Hyperlipidemia is a cardiovascular risk factor that by itself or when combined with cigarette smoking and sedentary behaviour as well as other risk factors presents a formidable problem for all NATO Air Forces as this directly impacts at pilot performance. Performance may also be affected by inadequate crew rest, environmental extremes and time zone shifts, all of which were recently illustrated in the Persian Gulf Conflict.

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P.T.O.

Nutrition
Diet
Hypoglycemia
Hyperlipidemia
Cardiovascular risk factors
Coronary artery disease
Cigarette smoking
Obesity
Aviation medicine
Caffeine
Lifestyle
Pilot performance
Jet-lag
Fatigue
Sleep
Environment
Desert Storm
Gulf conflict

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